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THE ARMOURED DINOFLAGELLATA: II. PROROCENTRIDAE  
AND DINOPHYSIDAE (B)—*DINOPHYSIS* AND  
ITS ALLIED GENERA

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*With 24 Text-figures*

Genus *Sinophysis* NIE & WANG

Although the two ventral hypothecal plates of *Sinophysis ebriolum* were described by BALECH (1956), the type of their arrangement is uncertain, because his drawings of the plate pattern in an intact state are least accurate. So far as concerned with his description and drawings, *Sinophysis ebriolum* seems to be a valid member of Dinophysidae.

Genus *Palaeophalacroma* SCHILLER

SCHILLER (1928) described two new species for which he established the new genus, *Palaeophalacroma*, characterized as follows; "Schalenpanzer durch die Sagitalnaht in zwei fast symmetrische Halften geteilt, deren jede aus einer Ober- und einer Unterschale besteht. Die Querfurche ist nicht ausgebildet; es tritt nur eine am oberen der unterschalen sitzende Leiste mit niedrigem Flügel auf, der unteren Querfurchenleiste bei *Phalacroma* oder *Dinophysis* entsprechend, und eine Längfurchenplatte, gleich jener dieser beiden Gattung, ohne Flügelbildung."

Both of his descriptions and drawings of these species are far from complete as in the cases of other species of well known genera, moreover no other authors have reported the species corresponding to his two species. On his drawings of these species, the proximal end of the single cingular list seems to be situated too much anteriorly to the flagellar-pore, it may rather be justifiable to regard the single cingular list representing, not the posterior but the anterior one of the paired lists invariably ascertained in all other genera of this family. So far as the sulcus is analyzed, it is hardly possible to discuss whether or not the structural relation of the sulcus in these species deserves a generic status. TAI and SKOGSBERG (1934) had no regard for this point, because the two species were provided already with a very distinctive

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character—entire lack of one of the two lists, which means an undifferentiated state of the cingular structure. In spite of SCHILLER's (1928, p. 64) description that "die Langsfurchenplatte wenig entwickelt und ohne Flügelleisten ist", one can see in the textfig. 27 of *Palaeophalacroma unicincta* two parallel short sutures seemingly representing the sulcus, whereas no trace of the sagittal suture is given in either of his drawings; this is suggesting that his drawings are inappropriate for taxonomical discussions.

### Genus *Dinophysis* EHRENCBERG

EHRENCBERG 1840: KENT 1881: BERG 1881: BÜTSCHLI 1896: DELAGE & HÉROUARD 1896: SCHÜTT 1896: PAULSEN 1908: JÖRGENSEN 1923: LEBOUR 1925: KOFOID & SKOGSBERG 1928: LINDEMANN 1928: SCHILLER 1928, 1931: PETERS 1930: TAI & SKOGSBERG 1934.

Syn.: *Phalacroma* STEIN 1883: BÜTSCHLI 1885: DELAGE & HÉROUARD 1896: SCHÜTT 1896: PAULSEN 1908: LEBOUR 1925: KOFOID & SKOGSBERG 1928: LINDEMANN 1928: SCHILLER 1928, 1931: PETERS 1930: TAI & SKOGSBERG 1934.

*Dinoceras* SCHILLER 1928. *Prodinophysis* BALECH 1944.

*Dinophysis* EHRENCBERG (1840) had been the first and only genus of the family, until *Phalacroma* was introduced by STEIN (1883). Since then, these two genera have been dealt with generally as distinct ones, although the arbitrariness of this generic separation was suggested by JÖRGENSEN (1923) and some difficulties in separating these two genera from each other were mentioned by KOFOID and SKOGSBERG (1928). The difficulties are due to incomplete characterizations of the two genera on the one hand and to frequent occurrences of intermediate forms on the other hand. And yet, without making accurate re-examinations of any essentially significant structural features, there is still now prevailing the concept that the degree of structural resemblance is commensurate to the degree of generic relationship.

The genus *Dinophysis* had been characterized by its relatively smaller or flattened epitheca, scarcely protruding anteriorly beyond the distal marginal brim of the anterior cingular list, while specimens with more strongly protruded epitheca were allocated to *Phalacroma*. This historical generic distinction is, however, quite conventional, and often meets the difficulties to see many intermediate forms and yet not to find out any other significant morphological difference. Not infrequently, a single specimen may be provided with features, some of which are characteristic of one genus, while others are of the other genus. Lesser or greater development of the megacytic zone often causes the change of the taxonomic allocation of the same species.

TAI and SKOGSBERG (1934) and the present author found the taxonomical importance of the structural relations within the sulcus and of the arrangement of the paired ventral hypothecal plates. Further, the present author could establish the closest relationship between the left sulcal list and the ventral hypothecal plates. Even these findings could not lighten the difficulty in distinguishing the two genera. On the contrary, it has become clear that the two genera agree with each other not

only in shape, size and structural relations of the sulcus but also in major cases in the features of the sulcus ending posteriorly at or about the middle of the hypotheca and of the paired ventral hypothecal plates extending only a little further beyond the sulcus. In these respects, *Dinophysis truncata* and *Dinophysis dens* form a sole exceptional group in which the two ventral hypothecal plates extend posteriorly to or nearly to the posterior end of the hypotheca. In this regard, these two species may be more closely related to *Histiophysis* or *Citharistes*.

There is a peculiar group comprising a few members with a biconical body shape, morphological features of which are, however, known almost incompletely. This *reticulatum* group, so named by KOFOID and SKOGSBERG, is uncertain, for the present author, as to its generic status. There has been recorded another incompletely known group, consisting of the species furnished with the antapical sail continuous to or distinct from the left sulcal list, the body of which is of the typical *Dinophysis*-type or of the typical *Phalacroma*-type. Judging from the published figures, the majority of members of this group is apparently to be allocated to the genus *Dinophysis*. Some questions remain about the generic allocation of *Dinophysis jörgensenii* KOFOID and SKOGSBERG (1928, pl. 5, fig. 3), because some inconsistent features are found in the beautiful drawing which was supposedly made without any mistake.

*Dinoceras* was established on only a few specimens and characterized by the paired spines standing on either side of the anterior end of the sulcus, but no other structural characteristics, really significant for its generic distinction, were not presented by SCHILLER. The generic name, *Prodinophysis*, has not been emphasized by BALECH since 1944.

*Dinophysis anabilis* n. sp.

Fig. 3 a-b.

A single specimen of this minute form was found in a plankton sample taken from Mutsu Bay on April 30, 1926. This species can be distinguished from any of

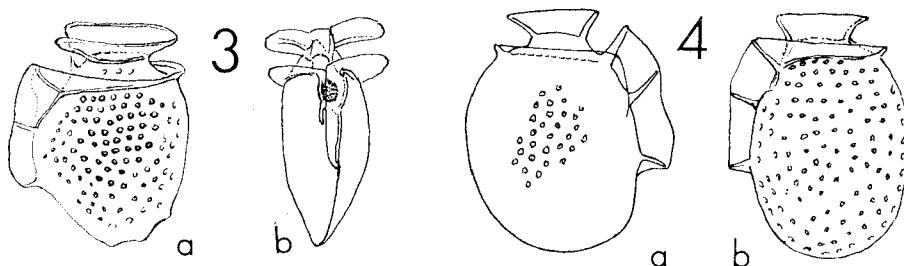


Fig. 3. a, b *Dinophysis anabilis* n. sp.

Fig. 4. a, b *Dinophysis arctica* MERESCHKOWSKY. All these figures and those in the following text-figures were prepared by camera lucida under various magnifications. For actual size, refer the dimensions of body given in the description of respective species.

reported species by its strongly angulated ventral side, smaller dimension of body and its wedge-shaped posterior end. It was certified that both of the ventral hypothecal plates are subequal in length and the left sulcal list is restricted to the range along these seriated ventral hypothecal plates, whereas the sulcus extends posteriorly beyond the fission rib of the left sulcal list but for only a short length.

Dimension: Length,  $30\mu$ . Dorsoventral dimension,  $25\mu$ . Lateral thickness of body,  $14\mu$ .

The closest relatives of this new species may be *Dinophysis semen* MEUNIER, *Dinophysis vertex* MEUNIER or *Dinophysis meunieri* SCHILLER. From the first of them, differs this in its stronger lateral flattening of the hypotheca and its more angulated ventral side of the hypotheca. From the second this can be distinguished by its more rotund body, much less asymmetrical lateral outline of the body and more strongly wedge-shaped posterior end of the body. From the last this differs in its more rounded antapical end of the body in lateral outline and its more pronounced biconvexed shape of the body in dorsoventral outline.

#### *Dinophysis arctica* MERESCHKOWSKY

Fig. 4 a, b.

*Dinophysis arctica* MERESCHKOWSKY, 1879, Pl. II, Fig. 19: PAULSEN, 1908, p. 15 (After CLEVE 1899):  
LEBOUR, 1925, p. 81, Fig. 20 f: SCHILLER, 1931, partim, p. 119, Fig. 112 b.

The present author examined two specimens, one from Mutsu Bay and the other from the Inland Sea of Japan. They appear to differ in some but in other points scarcely distinguishable from each other. Its flattened epitheca is small, in dorsoventral dimension 0.35–0.4 of hypotheca, and has the moderately deep cup-shaped anterior cingular list. The lateral outline of the hypotheca is moderately convex dorsally but faintly angulated ventrally at either or both of the fission rib and the third rib of the left sulcal list, and posteriorly fairly rounded evenly. The total length of the ventral hypothecal plates is about half as long as the hypotheca.

Dimensions: Length of body,  $35\mu$ . Transverse dimension,  $24$ – $28\mu$ .

Distribution: Mutsu Bay and the Inland Sea of Japan.

This has been recorded from Greenland, Spitzbergen, the North Sea, the East Sea and the Atlantic.

#### *Dinophysis infundibulus* SCHILLER

Fig. 5 a-j.

*Dinophysis infundibulus* SCHILLER, 1928, p. 76, Fig. 38.  
Syn.: *Dinophysis parva* SCHILLER, 1928, p. 77, Fig. 39.

The lateral outline of the body is broadly ovate, strongly contracting anteriorly to form a small epitheca which is distinctly convexed. The body is a little longer

than broad, but its hypotheca has subequal antero-posterior and dorsoventral dimensions. The lateral outline of the hypotheca bulges out most strongly in the middle or premedian on the dorsal side, but on the ventral in the middle or postmedian just at or shortly posterior to the third rib of the left sulcal list; both dorsal and ventral sides are confluent posteriorly to form a rounded postmargin of the body. The variation in shape and size of the lateral outline of the body is found only within a small limit, because the growth of the megacytic zone is made in the main in conformity with the original surface curvature of the thecal valves as illustrated in Fig. 5 *h*, resultantly it brings forth no distinct variation in shape and dimension of the lateral outline, but only a large increase of the bilateral dimension (Figs. *i* and *h*). One may see in Fig. *h* a remarkable dislocation of the ventral hypothecal plates brought by a pronounced development of the megacytic zone; here the anterior moiety is moved laterally by leftwards abrupt broadening of the anterior half of the sulcus. The lateral arrangement of the ventral epithecal plates is illustrated in Fig. *i*, and the meridional aspect of the secondary formed megacytic zone is shown in Fig. *j* which represents the lateral view of an isolated left dorsal hypothecal plate.

The anterior moiety of the ventral hypothecal plates is a little longer than the other moiety. The left sulcal list looks so strongly variable in shape and size as illustrated here. This is because the posterior half of the list bends more strongly towards the right than its anterior half.

Dimension: Length, 38–45  $\mu$ . Dorsoventral dimension, 36–40. Greatest lateral thickness, 20–31  $\mu$ .

Distribution: Mutsu Bay and Sagami Bay. Distributed presumably throughout the warm temperate waters of the Atlantic and the Pacific.

SCHILLER (1928) distinguished *Dinophysis infundibulus* from *Dinophysis parva* by more distinctly formed cingular lists in the former. But, they resemble each other so closely not only in size but also in shape of the body. Moreover, SCHILLER's descriptions and drawings of these species are so incomplete. Thus it seems better to the present author to treat these two species or forms as intraspecific variations of a single species.

#### *Dinophysis vanhoeffeni* OSTENFELD

Fig. 6 a-e.

*Dinophysis vanhoeffeni*, CLEVE 1900, p. 16, Pl. 8, Fig. 3.

Syn.: *Dinophysis punctata*, SCHILLER, partim, p. 120, Fig. 113 g (after CLEVE)

*Dinophysis borealis*, SOLUM 1962, Fig. 5<sub>1-5</sub>.

There have been recorded several small and closely allied forms mainly from the northern cold waters of the Atlantic. Their ultimate taxonomic treatments have been unsettled up to this time, because they hardly show any distinguishable morphological features on the one hand and these, seemingly different forms, can be

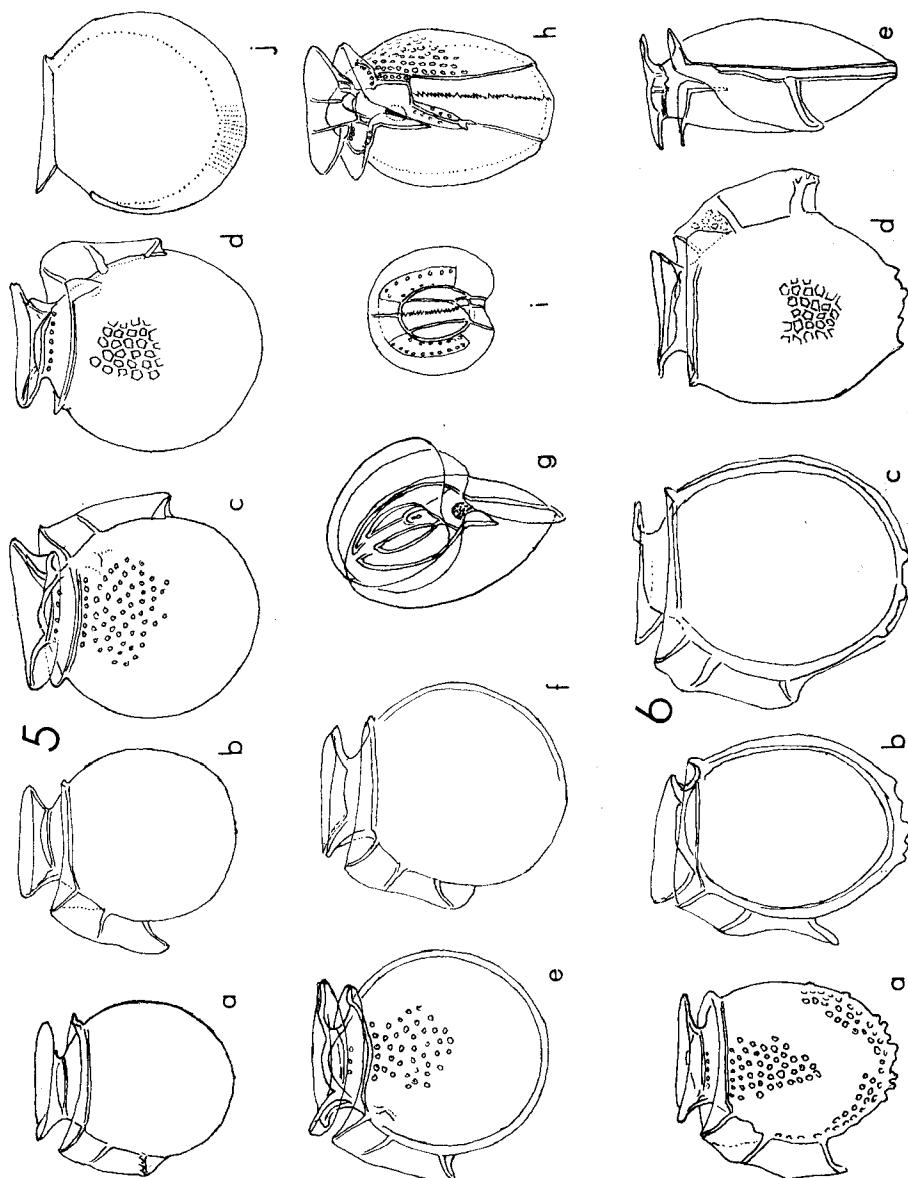


Fig. 5. *Dinophysis infundibulus* SCHILLER. *a-f*, represent five specimens differing somewhat in size, shape and morphology. *g*, an oblique anterior view of a specimen with the megacytic zone moderately built and showing the cingular lists decreasing the width from the right ventral to the left ventral across the dorsal, the rightwardly leaning left sulcal list bending to the right at its base, and the epithecal ventral paired-plate area demarcated fairly well. *h*, a ventral view of a fairly grown specimen showing a moiety of the fission rib dislocated in conformity to the anterior half of the sulcus broadened by a somewhat extended growth of the megacytic zone. *i* shows an apical view of the isolated epitheca and somewhat imperfectly isolated plates of the epitheca, with the fairly developed megacytic zone; ventral components of the cingular plates are lost but the midventral

linked together by intermediate forms on the other hand. These involve *Dinophysis acuminata* CLAP. and LACHM., *Dinophysis borealis* PAULSEN, *Dinophysis granulata* OSTENFELD, *Dinophysis lachmanni* PAULSEN, *Dinophysis punctata* CLEVE, *Dinophysis vanhoeffeni* OSTENFELD and some others.

CLEVE (1899) described from Spitzbergen "a very small form remarkable for its coarser structure" under the name *Dinophysis granulata* (p. 39, Pl. 4, Fig. 7), to which OSTENFELD (1889) had proposed already the name *Dinophysis vanhoeffeni*. CLEVE accepted *D. vanhoeffeni* to denote the typical form and reserved *D. granulata* for only the dwarf-form which is, according to him, "well characterized by its thick, coarsely areolated membrane, the upper part of which scarcely proceeds beyond the girdle".

Fig. 6 *a* in this paper, of the specimen collected from Mutsu Bay, corresponds almost exactly to CLEVE's Fig. 3, but for the rugged appearance along the postmargin of the body. This rugged appearance of the body is more or less pronounced in the majority of this species group. Number, arrangement and magnitude of these protuberances are subject to individual variation. It seems that the majority of former authors have mistaken in putting undue stress upon these structures of non primary importance in diagnosing this species. As illustrated in Figs. 6 *b-d*, the protuberances are apparently due to the outward thickening of the thecal wall presumably in association with the prolonged interfission phase brought forth under lower temperature of the ambient water and without any regularity in their arrangement. More essential feature, basing on which this species may be defined more distinctively, is to be found in its rather rotund body shape, bulging moderately on both the ventral and dorsal sides. As illustrated in Fig. 6 *e*, the left sulcal list is sigmoid, leaning more strongly towards the right in its posterior two-thirds. In consequence, the shape of the list in lateral outline is variable according to small changes of the direction of observation.

Dimension: Length, 42–50  $\mu$ . Largest dorsoventral dimension, 31–40  $\mu$ .

Distribution: Mutsu Bay, the Adriatic Sea, northwest coastal waters of Norway.

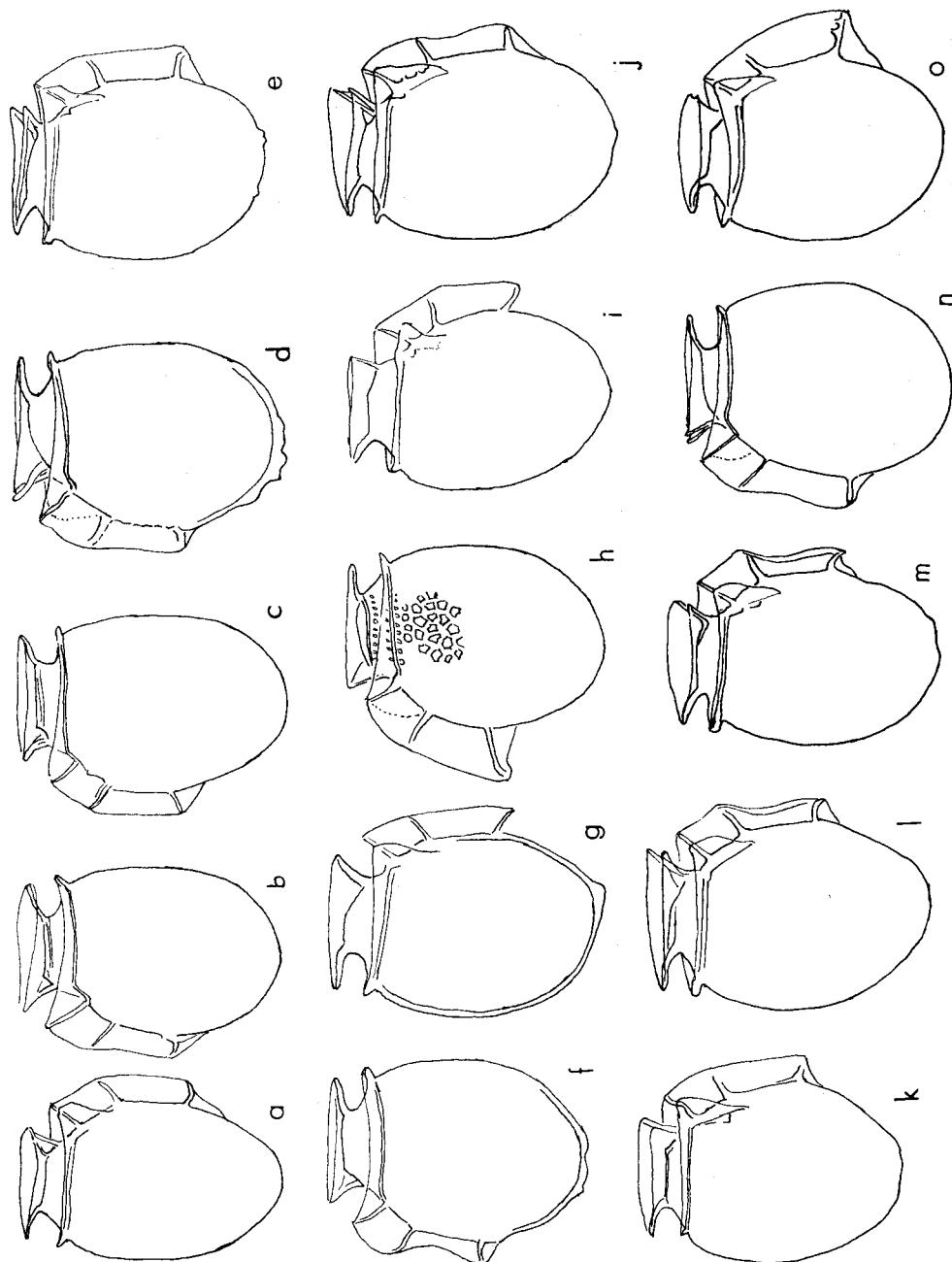
*Dinophysis acuminata* CLAP. & LACHM.

Fig. 7 a-y.

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moiety of the epithecal plates is clearly illustrated together with their ventrally extending cingular list. *j* is a side view of an isolated dorsal left hypothecal plate, indicating the detached trace of the anterior moiety of the ventral hypothecal plates and the variable breadth of the growth zone around the hypotheca.

Fig. 6. *Dinophysis vanhoeffeni* OSTENFELD *a*, a round specimen with rugged outer surface, particularly prominently along the posterior sutural zone. *b-d*, somewhat larger specimens with different surface ruggedness and the left sulcal list differently shaped. *e*, ventral view of a specimen showing the posterior half of the left sulcal list, slanting towards the right so strongly that it assumes superficially a quite strange shape in its lateral outline.



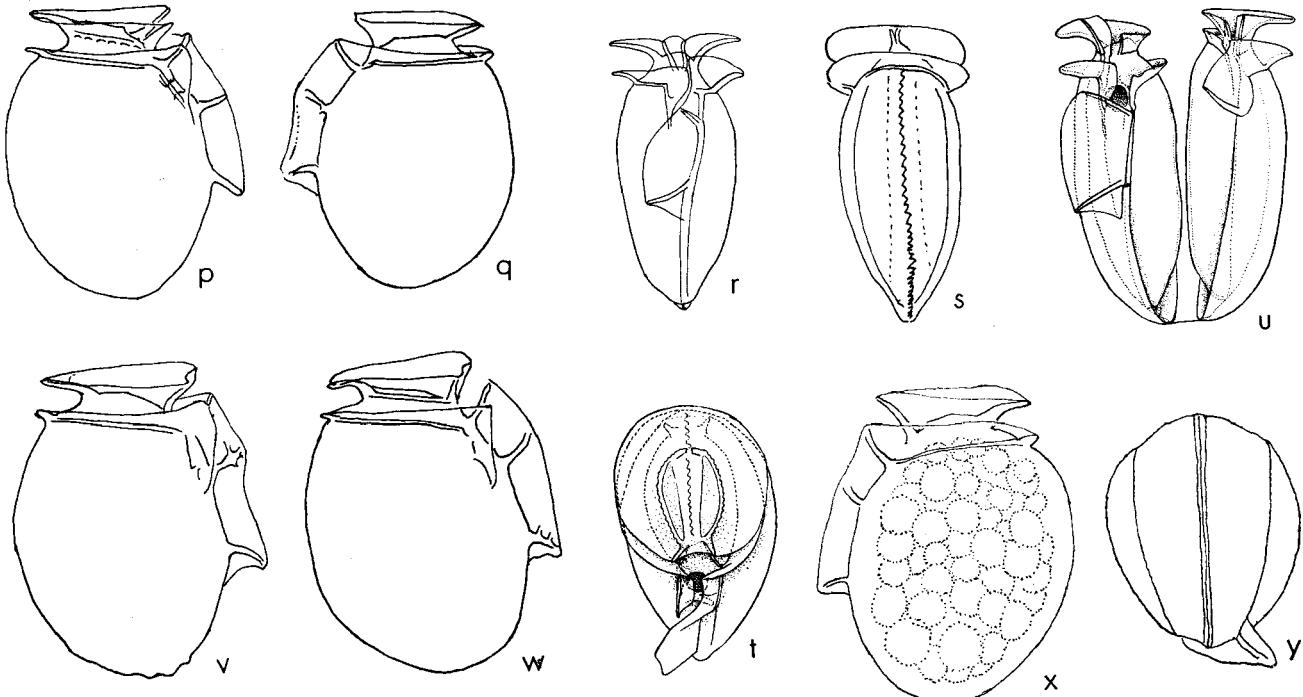


Fig. 7. *Dinophysis acumina* CLAP. & LACHM. *a-q, v, w, x*, side views of specimens differing from one another in some points. *r* and *t*, ventral and anteroventral views of specimens, showing a strong rightward bending of the left sulcal list, and in *t*, is shown the formation of the growth zone. *s*, dorsal view of a specimen with the megacytic zone moderately built, which brings forth variations in length, breadth and lateral outline of body. *u*, ventral view of two daughter specimens just after binary fission. *y*, antapical view of *x*-specimen with the extremely broad megacytic zone.

*Dinophysis acuminata*, JÖRGENSEN 1899, p. 30, Pl. I, Figs. 7-9; 1923, p. 22, Fig. 25: PAULSEN 1908, p. 15, Fig. 13: LINDEMANN, 1924, Figs. 8, 9: LEBOUR 1925, partim, p. 80, Pl. 12, Fig. 2a: WOŁOSZYNSKA 1929, p. 167, 228, 252, Pl. 4, Figs. 5-8, Pl. 5, Fig. I: SCHILLER 1931, p. 120, partim, Fig. 112 a-d: BALECH 1944, partim, p. 432, Figs. 18-20: TAI & SKOGSBERG 1934, p. 430, Fig. 4 a-t: WOOD 1953, p. 195, partim, Fig. 38 a.

Syn.: *Dinophysis lachmanni*, SOLUM 1962, Fig. 2<sub>1-16</sub>, Fig. 5<sub>4-6</sub>, Fig. 9<sub>1-15</sub>.

KOFOID and SKOGSBERG (1928) regarded this species as a collective species, while SCHILLER (1931) considered it as a highly variable species, involving in it several superficially different forms figured by various authors. Prior to them, JÖRGENSEN (1899) observed a form off the west coast of Norway, which differed, according to SOLUM (1962), considerably from that shown in CLAPAREDE and LACHMANN's illustration, but he referred it to *Dinophysis acuminata*. Later the same author (1912) collected from the same locality specimens practically identical with that figured by CLAPAREDE and LACHMANN. PAULSEN (1912) suggested that *Dinophysis acuminata* might be better divided into two to several species. KOFOID and SKOGSBERG (1928) mentioned that the form described by JÖRGENSEN (1899) differed from CLAPAREDE and LACHMANN's original one. Fairly later, PAULSEN (1949) proposed to reserve the name *Dinophysis acuminata* for only the cells which conform to CLAPAREDE and LACHMANN's form which is characteristically much broader in the posterior than in the anterior part and with a small triangular posterior protuberance slightly ventral to the midline. He distinguished *Dinophysis lachmanni* PAULSEN as a new species which included the *Dinophysis acuminata* specimens of JÖRGENSEN (1899). In addition, he described the new species *Dinophysis borealis* PAULSEN and referred to it several forms treated under the name of *Dinophysis acuminata* by various authors. SOLUM himself (1962) shows some confusions in diagnosing the species; he is suggesting on the one hand that " *Dinophysis lachmanni* and *Dinophysis borealis* do not deserve specific status", but regarding them as "forms of one species", and on the other hand he is treating them in his descriptions either as *Dinophysis lachmanni* and *Dinophysis borealis* or as *D. lachmanni* f. *lachmanni* and *D. lachmanni* f. *borealis*. Difficulties in diagnosing these small species may clearly be seen in SOLUM's comment that "It would have been most practical if we could have included them in *D. acuminata* CLAP. et LACHM., since cells of this kind repeatedly have been referred to as *D. acuminata*, but we find that we shall have to follow PAULSEN (1949) since he reserves the name of *D. acuminata* for cells which strictly conform to the illustration accompanying CLAPAREDE and LACHMANN's description." PAULSEN distinguished *D. lachmanni* from *D. borealis* mainly by differences in number of the antapical protuberances and in length and length/breadth ratio of the body, disregarding variations due to growth.

In Fig. 7 are shown lateral outlines of twenty different specimens, belonging in all probability to a single species, all of which resemble one another as a whole, but showing some differences in some points. All these figures were selected out of sixty sketches prepared by camera lucida. The dorsal side of the hypotheca is bulging fairly evenly between the levels of the second and the third ribs of the left sulcal

list (in *a-g, j*, and *m*), more or less curved abruptly at the level of the third rib (in *h, k, n-q*), or bulging more strongly posteriorly than anteriorly between the two ribs (in *b, d, f, i, l, n* and *m*). The ventral side of the hypotheca is more or less gently convex as a whole (in *a-h, j, l, m-o, v, w*), or more pronouncedly just below the cingulum (in *i, k, p*). The antapex is in posteromedian (in *a-f, i-k, m-o*) or somewhat dislocated ventrally (in *g, h, p, q, v, w*); one or more posterior protuberances may be seen there (in *d, f, g, w*). In addition, the actual body length or the length/breadth ratio differs from specimen to specimen. The shape and size of the left sulcal list differs considerably according to different directions of observation for the reason shown for the preceding species (refer figures *r* and *t*). Taken these variations into account, it may scarcely be possible to subdivide the cell-group here treated into well defined forms, subspecies or species. For instance, the *x-y* specimen with the anterodorsal side of the hypotheca distinctly bulged just posterior to the cingulum and with the extremely grown megacytic zone can be dealt with as a megacytic form of the *k-* or *p*-type specimen. If the three figures *s, u, y* are compared one another, it will be understood very easily that the growth or megacytic zone in this group of specimens might have been settled more and more medianwards in conformity to the prominent enhancement of the megacytic growth, which, then, might bring about polymorphic variations in the general feature of the body.

It seems to be a very significant feature that in species with the fairly flattened epitheca the ventral portion of the epitheca is more or less sharply concaved and looks in lateral outline bent down ventrally for a short distance, and that this differentiated ventralmost portion of the epitheca is the area covered with the ventral epithelial plates.

Dimension: Length, 42-53  $\mu$ .

Distribution: Mutsu Bay, northern regions of both the Atlantic and the Pacific.

Apart from the thoughts of PAULSEN, KOFOD & SKOGSBERG, SCHILLER, SOLUM and some others, the present author has gradually come to embody his own interpretation as to the causal relationships between the variations in size and shape of the body and the growth of the megacytic zone. The intraspecific variations generally left unexplained as a perennial puzzle in the taxonomy of such smaller species as this may be explained to some extent basing on this interpretation. In this respect, it seems to be very helpful to think of, in advance, the extreme irregularity of the formation of the megacytic growth in *Dinophysis elongatum* (Fig. 24). This will be enough to convert the widely accepted misinterpretations that the megacytic growth emerges at first evenly all around the body along its sagittal suture, that two exactly identical daughter specimens are formed by fission, and furthermore that the formation type of the growth zone is invariably constant in every case. In reality all of these misinterpretations are to be noted carefully when considerations are paid in regard to rather smaller species inclusive of *Dinophysis acuminata* and some others. The conventional concepts hitherto accepted will do nothing, but only bring forth taxonomical confusions as referred to briefly in the beginning of this paragraph.

The intraspecific variations, then, can not be discussed disregarding the degree and the regularity or irregularity of growth of every examined specimen.

*Dinophysis lenticula* PAVILLARD

Fig. 8 a-f.

*Dinophysis lenticula*, JÖRGENSEN, p. 23, Fig. 27; LEBOUR 1925, p. 81, Pl. 12, Fig. 4.  
Syn.: *Dinophysis recurva*, SCHILLER 1931, partim, p. 111, Fig. 105 b.

Though the validity of this species has often been regarded as questionable, it seems rather desirable to treat this as a distinct one till more crucial morphological studies of such a smaller species will be done by some one in future.

The lateral outline is a little larger than in the preceding species. The epitheca is a little larger in dorsoventral dimension than in the preceding species, and

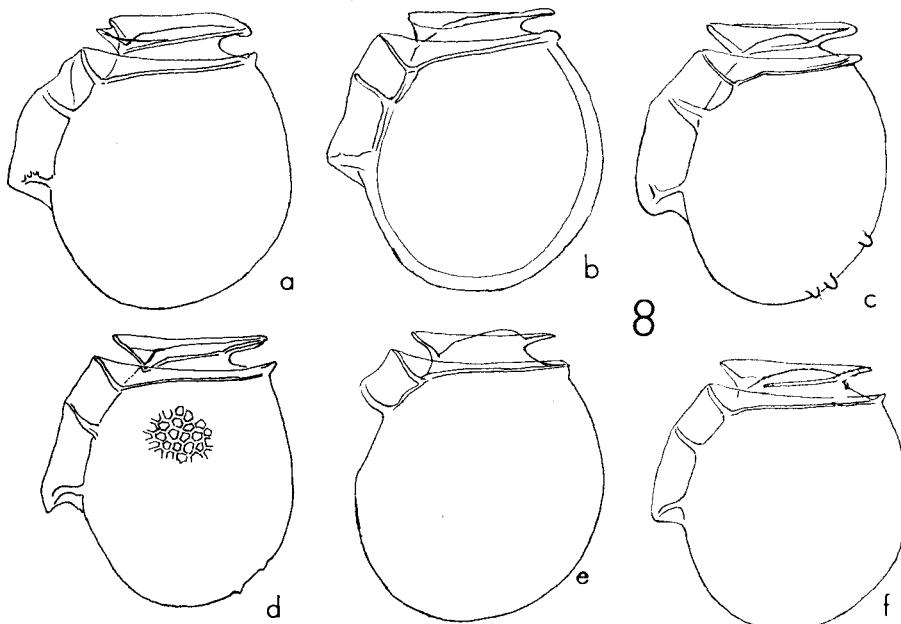


Fig. 8. *Dinophysis lenticula* PAVILLARD. a-f, side views of six different specimens. In c and d, there can be seen one to several antapical protuberances. e, represents a left-sided specimen just after binary fission.

a little more strongly convex, extending nearly to but not beyond the distal free margin of the anterior cingular list. Fig. 8 e represents a disjoined left valve under very slight pressure given on the coverglass from above, consequently the convexity of the epitheca is somewhat exaggerated. Such an appearance can not be met with in the preceding species. The hypotheca is moderately rounded ventrally and dorsally,

with its greatest dorso-ventral dimension at the level of the third rib of the left sulcal list. The anterior half of the ventral side, occupied by the paired ventral hypothecal plates, is fairly straight in its lateral outline and lying distinctly aslant to the cingular plain, but not forming any distinct angle at the third rib. Posteriorly, the body margin is broadly rounded fairly evenly; the practical posterior end of the body is median or slightly displaced ventrally, and not so acutely rounded as seen in fig. *v* or *w* of the preceding species (Fig. 7).

The total length of the paired ventral hypothecal plates is subequal to or a little larger than the dorso-ventral dimension of the epitheca, which is about two-thirds of that of the hypotheca at the level of the posterior cingular edge. The greatest dorso-ventral dimension of the hypotheca is about twice the total length of the paired ventral hypothecal plates extending between the first and the third ribs of the left sulcal list, but a little smaller than the length of the hypotheca.

Dimension: Length, 45–50  $\mu$ . Greatest dorso-ventral dimension of hypotheca, 35–40  $\mu$ .

Distribution: Mutsu Bay, the Mediterranean Sea, the Adriatic Sea, the Plymouth sound. According to LEBOUR, this occurs in closer inshore waters as compared with *Dinophysis acuminata*.

#### *Dinophysis okamurai* KOFOID & SKOGSBERG

Fig. 9 a-c.

*Dinophysis okamurai* KOFOID & SKOGSBERG 1928, p. 250, Fig. 31<sub>5</sub>; SCHILLER 1931, p. 123, Fig. 116 a: WOOD 1953, p. 196, Fig. 38 b.

Syn.: *Dinophysis vanhoeffeni*, OKAMURA, 1907, partim, p. 131, Pl. 5, Fig. 41 c.

*Dinophysis acuminata*, MARTIN 1929, partim, Pl. 8, Fig. 6.

Under the name of *Dinophysis vanhoeffeni*, OKAMURA reported three different forms from the eastern coast of Japan, to one of which was given the name *Dinophysis*

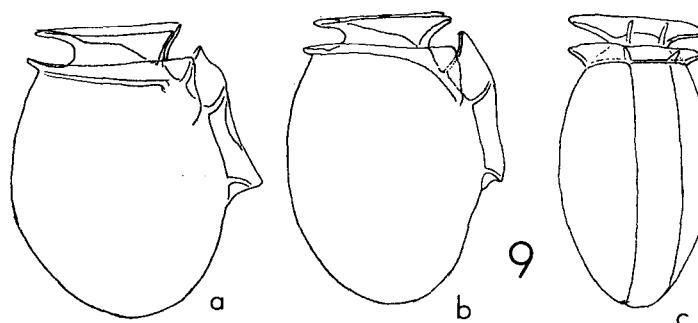


Fig. 9. *Dinophysis okamurai* KOF. & SKOGSBG. *a-b*, represent side views of two different specimens. *c*, dorsal view of a specimen with the megacystic zone moderately formed.

*Okamurai* by KOFOID & SKOGSBERG (1928). OKAMURA's figure is incomplete because it lacks the anterior half of the left sulcal list, this clearly suggests that the specimen represents a right-hand daughter cell just after binary fission. Nevertheless, his figure presents sufficient characteristic features worthy to distinguish this from others. So far illustrated, its elongated body has the gently convexed dorsal side and the ventroposterior portion of the ventral side much less convexed, while its anterior portion in front of the fission rib is distinctly aslant, making the body contact anteriorly to the fairly small epitheca only on the ventral.

The present author found a form exactly coinciding with OKAMURA's specimen from Mutsu Bay and a somewhat aberrant form from the Inland Sea of Japan. The body is about 1.4 times longer than deep in both specimens. This length/depth (dorso-ventral dimension) ratio seems to be least variable, as the growth of the megacytic zone is carried on in these specimens in the lateral direction, in which the body is fairly flattened, but, not along the original curvature of respective thecal valves. In these respects, *Dinophysis baltica* of WOŁOSZYNSKA (1928, partim, Pl. 4, Fig. 4) and *Dinophysis levanderi* of the same author (Ibid., Pl. 4, Fig. 3) appear to be the closest relatives of this species.

Dimensions: Length, 50–53  $\mu$ . Greatest dorso-ventral dimension, 38–42  $\mu$ .

Distribution: Eastern coastal waters of Japan, warm temperate coastal waters of the East Pacific near Callao of South America.

### *Dinophysis ovum* SCHÜTT

Fig. 10 a-p.

*Dinophysis ovum* SCHÜTT, 1895, Pl. Fig. 6: PAULSEN 1908, p. 17, Fig. 16: JÖRGENSEN 1923, p. 22, Fig. 26: LEBOUR 1925, p. 81, Pl. 12, Fig. 3: SCHILLER 1931, p. 116, Fig. 109 (after LEBOUR): WOOD 1953, Fig. 35 a-c.

Syn.: *Dinophysis rotundata* var. *intermedia* LINDEMANN, 1924, Fig. 10.

*Dinophysis brevisulcus* TAI & SKOGSBERG, 1934, partim, p. 430, Fig. 3 a-k.

*Dinophysis acuminata*, BALECH, 1944, partim, p. 432, Pl. 2, Fig. 21.

*Dinophysis sphaerica*, WOOD 1953, p. 195, Fig. a, b (not c).

*Dinophysis parva* SCHILLER 1928, p. 77, Fig. 39; 1931, p. 111, Fig. 103: GAARDER, 1954, p. 20, Fig. 21.

*Dinophysis antarcticum* BALECH, 1958, p. 82, Pl. 2, Figs. 14–25.

The lateral outline of the body is broadly ovate, with the slightly convexed epitheca. The posterior margin of the body is moderately rounded and its tip is situated somewhat ventral to the median line when the body is placed with the cingular plain horizontal. The longitudinal dimension of the hypotheca is only a little greater than the dorsoventral dimension which shows the maximum at, just in front, or in rear of the level of the third rib of the left sulcal list. The dorso-ventral dimension of the hypotheca at the level of the posterior cingular ridge is about 1.5 times as large as that of the epitheca, the latter is 0.7–0.8 of the total length of the

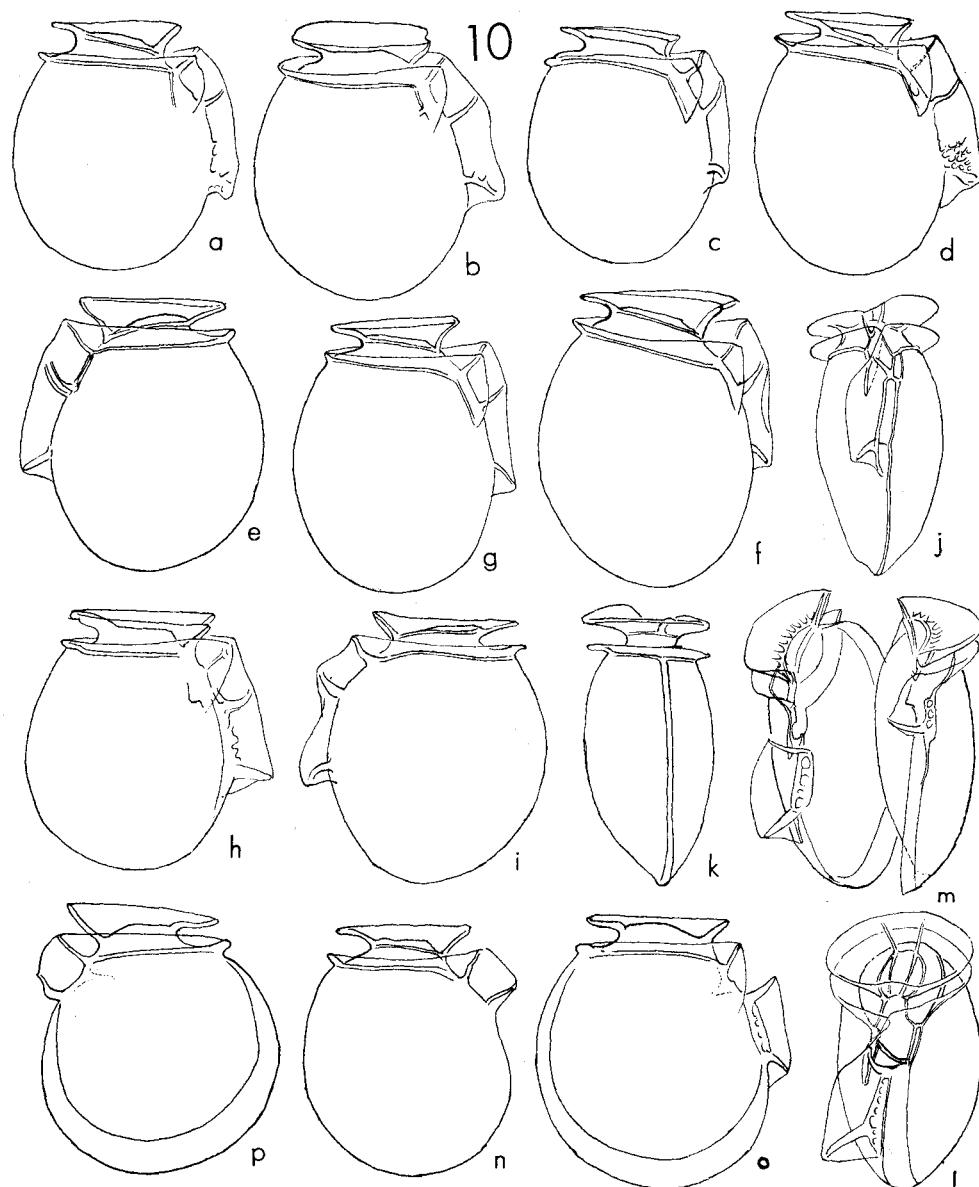


Fig. 10. *Dinophysis ovum* SCHÜTT. *a-i*, represent nine specimens respectively with different lateral outline. *n*, right side view of a left-handed daughter specimen just after binary fission. *o* and *p*, lateral views of a right and a left isolated valve, showing the variable breadth of the subsutural growth zone. *k* and *j*, represent respectively the dorsal and the ventral view of a specimen before the megacytic zone grows wider. *l*, anteroventral view of a specimen with the megacytic zone moderately built. *m*, anteroventral view of linked two specimens just after binary fission.

paired ventral hypothecal plates.

Some specimens of this species can hardly be distinguished from *Dinophysis lenticulata*. Even in such cases, however, the present species may be separable from *D. lenticulata* by its smaller and less convexed epitheca and its relatively smaller dorso-ventral dimension of the body. Lateral outlines of nine different specimens (Fig. 10 a-i) are presented here to show the range of variations in size and shape of the body. In Fig. 10 e is illustrated the paired structure of the fission rib, which undoubtedly indicates the existence of the fairly broad megacytic zone. Fig. 10 n is the right side view of a left-hand daughter cell just after the binary fission, because the posterior half of the left sulcal list is scarcely formed. As clearly illustrated in Fig. 10 m, the megacytic zone is built in conformity to the original curvature of the thecal wall. Then, the present author separated the two valves of a megacytic form from each other for the purpose of studying the exact process of the megacytic zone formation; the valves thus isolated are shown in Fig. 10 o and p. The megacytic zone is built all around the body, with its maximum growth in the posterior median region and coming narrower towards the cingulum. This clearly indicates a progressive variation in the length/depth ratio of the body in accord with the increase in breadth of the megacytic zone. In this type of the megacytic growth, variations due to the growth is least in the epitheca, but shown most prominently in the total length of the body and in the dorso-ventral dimension of the hypotheca. Another portion of the body which is scarcely affected by the megacytic growth is the total length of the paired ventral hypothecal plates; the anterior moiety of the plates is dislocated laterally by the growth of the megacytic zone, but the total length throughout the plates, observable in side view of the body, remains constant. This is the principal reason why the present author takes up in this paper both the dorsoventral dimension of the epitheca and the total length of the ventral hypothecal plates as the most reliable indexes for body measurement. However, there may be different types of the megacytic zone formation. In specimens or species with the megacytic zone increasing its breadth dorsally, the portion affected least by the megacytic growth must be limited to the total length of the paired ventral hypothecal plates.

Dimension: Body length, 46-57  $\mu$ . Greatest dorsoventral dimension, 57-50  $\mu$ .

Distribution: Mutsu Bay. The southwest waters of Ireland, Spanish Bay, the Adriatic Sea, the Gulf of Finland, the Atlantic Ocean, the Mediterranean Sea, the Antarctic Sea, and the coastal waters of the northwestern Pacific.

*Dinophysis lapidistrigiliformis* n. sp.

Fig. 11 a-f.

The body is small and laterally flattened. In dorsoventral view the body is laterally convex, but in lateral view it is somewhat obliquely elongated ovoid and broadly truncated anteriorly. The epitheca is only slightly convex, and the cingular

lists are relatively broad and expanded anterolaterally. The dorsal side of the hypotheca is weakly convex as a whole, whereas the ventral side is nearly straight in its anterior 0.6–0.7, along which lie the ventral hypothecal plates, and slightly angulated at either the fission rib or the third rib. The total length of the ventral hypothecal plates is subequal to the dorsoventral dimension of the hypotheca at the level of the posterior cingular ridge. The sulcus extends posteriorly shortly beyond the fission rib.

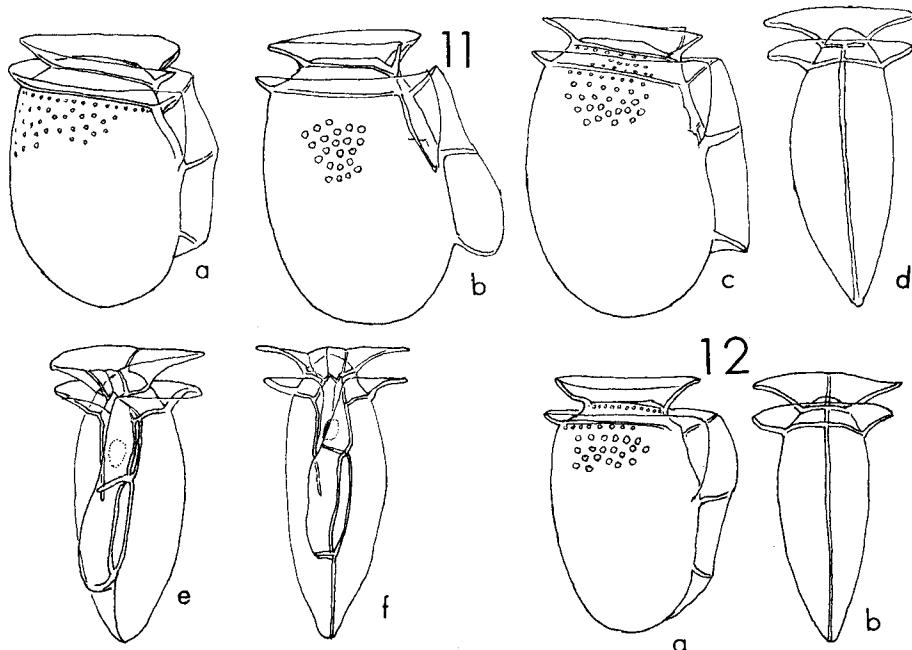


Fig. 11. *Dinophysis lapidistrigiliformis* n. sp. a-c, side views of three different specimens. d-f, a dorsal and two ventral views of different specimens.

Fig. 12. *Dinophysis microstrigiliformis* n. sp. a, b, rightside and dorsal views.

Several specimens only were observed in the material collected from Mutsu Bay in the end of April, 1926, but no further specimens were found in the material collected there in the following four years.

Dimension: Length, 50–55  $\mu$ . Greatest dorsoventral dimension, 30–35  $\mu$ . Lateral dimension, 18–22  $\mu$ .

#### *Dinophysis microstrigiliformis* n. sp.

Fig. 12 a-b.

Only a single specimen of this new species was found in the same material in which the preceding species was detected. It is not impossible to conclude that

the present form represents merely an aberrant form of the preceding species. However, it seems to the present author rather desirable to separate this provisionally as a distinct species, because of its smaller size, less bulged lateral valves, much less obliquely elongated body shape and relatively longer left sulcal list extending further beyond the third rib nearly to the antapex, besides the entire lack of intermediate forms. The total length of the paired ventral hypothecal plates occupies anterior 0.7 of the hypotheca.

Dimension: Length,  $45\ \mu$ . Greatest dorsoventral dimension,  $38\ \mu$ .

*Dinophysis forti* PAVILLARD

Fig. 13 a-k.

*Dinophysis forti* PAVILLARD, 1923, p. 881; KOFOID & SKOGSBERG 1923, p. 253, Fig. 37; TAI & SKOGSBERG 1934, p. 439, Fig. 5 a-d, Pl. 11, Figs. 1-4, Pl. 12, Figs. 1-9.

Syn.: *Dinophysis laevis*, POUCHET 1883, p. 426, Pl. 18-19, Fig. 6.

*Dinophysis intermedia*, PAVILLARD 1916, p. 58, Pl. 3, Fig. 4; FORTI 1923, p. 110, Fig. 119; JØRGENSEN, 1923, p. 19, Fig. 21; ABÉ, 1927, p. 384, Fig. 1.

*Dinophysis ovum*, MARTIN, 1929, p. 21, Pl. 2, Fig. 10, Pl. 8, Fig. 5.

The morphology of this species was fairly well analyzed by TAI & SKOGSBERG, but with some misinterpretations and improper illustrations. The range of variations found in the lateral outline of the body is given in Fig. 13 a-d. The ventral side of the hypotheca is fairly straight in its anterior half between the first and the third ribs of the left sulcal list, slanting to the cingular plane keeping constantly an angle of  $110-120^\circ$  between it and the plane. The variations are mostly confined to the situation and degree of the dorsal bulge of the hypotheca. In this regard, it is to be noticed that the moderate megacytic zone becomes broader on the ventral towards the antapex as illustrated in Fig. 13 k, and that the breadth of the zone at the antapex is much greater as compared with the distance between the paired dorsal ribs of the anterior cingular list, which represents the greatest breadth of the zone in the epitheca. The latter aspect suggests clearly that the megacytic zone on the dorsal side extends further anteriorly, but coming narrower towards the cingulum as in the case shown in Fig. 16 g.

Fig. 13 f represents the inside view of an isolated left dorsal hypothecal plate, along the ventral margin of which one can see an indent showing the situation of the detached anterior moiety of the ventral hypothecal plates, just posterior to the cingular list. On the contrary, Fig. 13 e represents the outside view of an isolated right dorsal hypothecal plate. Judging from the structures exhibited along the ventral margin of this valve, it is suggested that the right sulcal list and the sulcus terminate posteriorly at the levels entirely corresponding to each other, while the posterior moiety of the ventral hypothecal plates extends further posteriorly to the third rib of the left sulcal list which is represented by the anterior edge of the small triangular

list in Fig. *e*. It is to be noticed that a minute triangular list is seen, as shown in Fig. 13 *j* and *k*, standing transversely along the entire posterior margin of the sulcus and increasing its height towards the left sulcal list. Taking this into account, together with the spiral tract of the girdle, the existence of the broad left sulcal list closely along the left side of the sulcus, and a zigzag folding of this list at the doubled

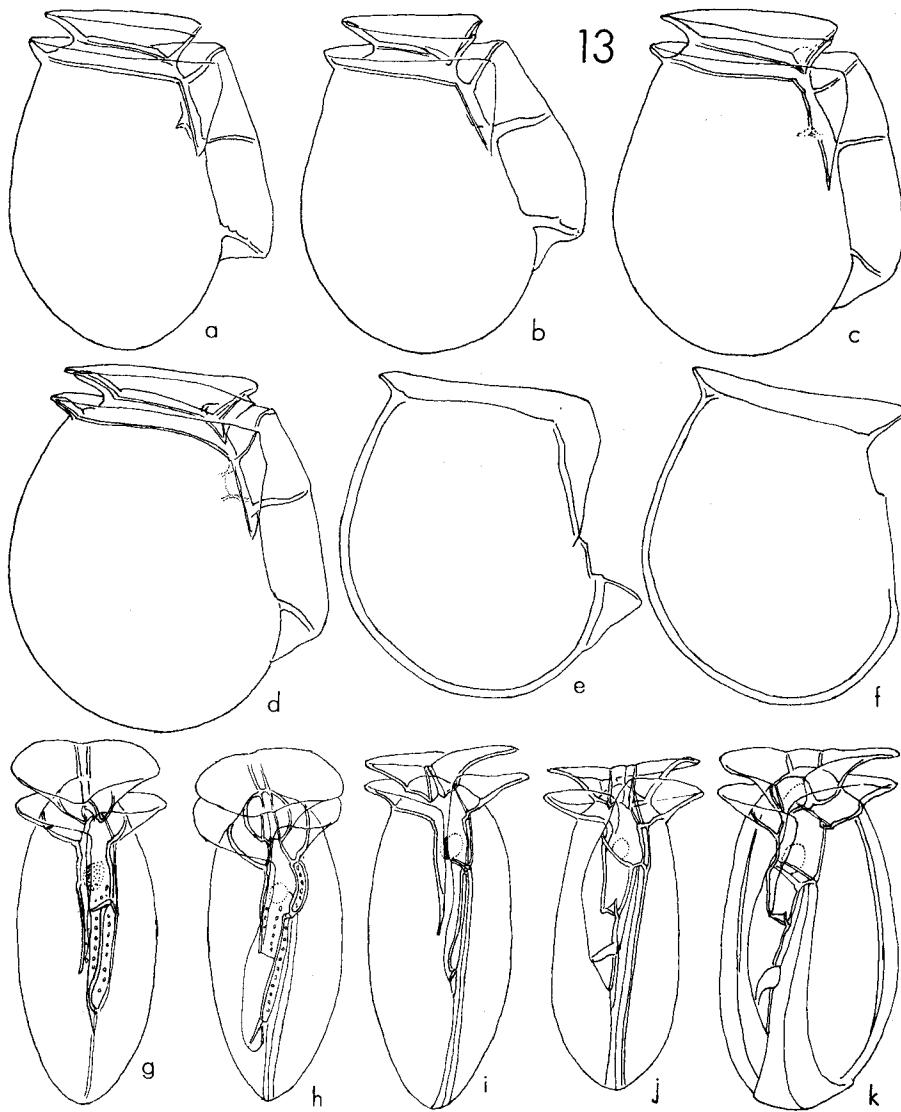


Fig. 13. *Dinophysis forti* PAVILLARD. *a-d*, right lateral views of four specimens, differing one another in some features. *e* and *f*, right lateral views of the right and the left dorsal hypothecal plates. *g-k*, ventral views of various specimens with the megacytic zone of different breadths. In *g-j*, are illustrated the two ventral hypothecal plates.

fission rib in megacytic forms, it is suggested that the trailing flagellum is so directed as to induce an oblique water current within the sulcus running from the left anterior corner to the right posterior. The relative size and the arrangement of the two ventral hypothecal plates and various stages of the megacytic growth are shown in respective ventral views of the body in Fig. 13 *g-k*. Comparative study of these figures uncovers clearly that the duplex cingular list exhibits a slight tilt towards the right as a whole, and the cingular tract forms a descending spiral as clearly illustrated in Fig. 13 *i* or *k*. Similar features are shown in Fig. 5 *h*, Fig. 6 *e*, Fig. 7 *r*, Fig. 10 *j* and *k*, Fig. 11 *d-f*, and Fig. 12 *b*. This reminds one of the report by SCHILLER (1928) showing that the single equatorial suture of *Palaeophalacroma* indicates a descending spiral tract just as in the cases cited here.

Dimension: Length, 56–83  $\mu$ . Greatest dorso-ventral dimension, 43–58  $\mu$ . Greatest lateral dimension, 27–32  $\mu$ .

Distribution: Mutsu Bay, Sagami Bay, the Inland Sea of Japan. Distributed in all probability throughout the subtrropic and the temperate waters.

#### *Dinophysis caudata* SAVILLE-KENT

Fig. 14 a-d.

*Dinophysis caudata*, JÖRGENSEN 1923, p. 24, Figs. 30–34; KOFOID & SKOGSBERG, 1923, p. 312, Figs. 44, 45; SCHILLER 1921, p. 153, Fig. 145 *a-u*; BALECH 1944, p. 436, Figs. 42–56; 1951, p. I, Figs. 1–76; WOOD 1963, Fig. 49 *a-e*.

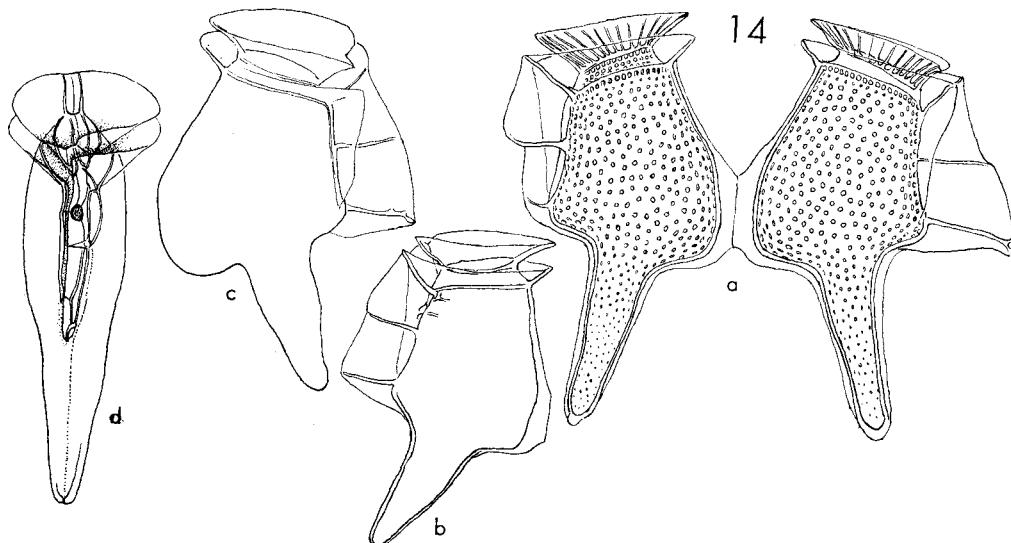


Fig. 14. *Dinophysis caudata* SAVILLE-KENT. *a*, two daughter specimens linked together on the dorsal. *b*, left side view of a specimen with the dorsal side less bulged. *c*, right side view of a specimen with a pronounced dorso-posterior bulge. *d*, ventral view, showing the four sulcal plates and the two ventral hypothecal plates.

Because of its peculiar body shape, incomparably wide distribution, and very frequent occurrences on the one hand and owing to the deficiency of their knowledge as to the range of variations in body shape on the other hand, this species has attracted many authors to offer so various and different principles of subdividing the species. Partly because of surprisingly wide distribution of this species throughout the tropical, the subtropic and the cold waters of the world, and partly due to the fact that in diagnosing species, subspecies, variety or form, too much stress has generally been put on the variations in size, shape, and length of the postero-dorsal bulge of the body, the present author will refrain from discussing taxonomical status of various aberrant forms observed. In other words, it may be accused for incautiousness to discuss this without ascertaining by himself the interrelationships between the distributions of respective aberrant forms or variants and the chemical and physical conditions of the waters where they were collected, and in the circumstance that collected stations were not distributed all over the oceans. At present, our knowledge above these points is evidently too insufficient.

BALECH's (1951) elaborate morphological analyses of this species are fairly accurate and far-reaching as a whole, still incomplete in regard to the ventral area, because all of the sulcal elements are figured separately and from different sides. In consequence, it is difficult for most readers to reconstruct the intact morphological state of the sulcus. For the purpose to cover this, Fig. 14 d is selected out of many sketches made by the present author to show the mutual relation between the sulcal plates, the flagellar pore, and the ventral epithecal and hypothecal paired plates.

Dimension: Length, 75–103  $\mu$ . Greatest dorso-ventral dimension, 37–50  $\mu$ .

Distribution: Frequent occurrences in the tropical and the subtropical water, not infrequent in the cold waters, too.

*Dinophysis rotundata* CLAP. & LACHM.

Fig. 15 a-h.

*Dinophysis rotundata*, BERG, 1881, p. 224, Fig. 16: STEIN 1883, Pl. 19, Figs. 9–11, Pl. 20, Figs. 1–2: SCHÜTT, 1895, Pl. I, Fig. 5.

Syn.: *Phalacroma rotundatum*, KOFOID & MICHENER, 1911, p. 290: JÖRGENSEN, 1923, p. 5, Fig. 2: SCHILLER 1931, partim, p. 67, Fig. 60 d: TAI & SKOGSBERG, 1934, partim, p. 426, Fig. 2 a-l: BALECH, 1962, p. 124, Pl. 16, Fig. 204.

This species is characterized by its almost circular lateral outline of the body, broad and sharply angulated left sulcal list and particularly by its low and fairly evenly rounded epitheca. In dorso-ventral view, the body is symmetrically bi-convex with the greatest lateral dimension in the middle of the body and ending more sharply posteriorly than anteriorly (Fig. 15 h). As in *Dinophysis rudgei*, the anterior moiety of the paired ventral hypothecal plates is a little shorter than the other moiety (Fig. 15 a-e, h). Fig. 15 f and g represent respectively the apical view and the vent-

ral side of different megacytic forms. Various stages of the megacytic growth were studied, of which an example of the extraordinary megacytic growth is represented by the *g*-specimen. It is concluded on these observations that the growth of the megacytic zone is minimal on the ventral invariably at the level of the anterior cingular list and maximal in the postero-dorsal region of the hypotheca. It is to be noticed in this respect that in specimens with the megacytic zone of a moderate breadth, the

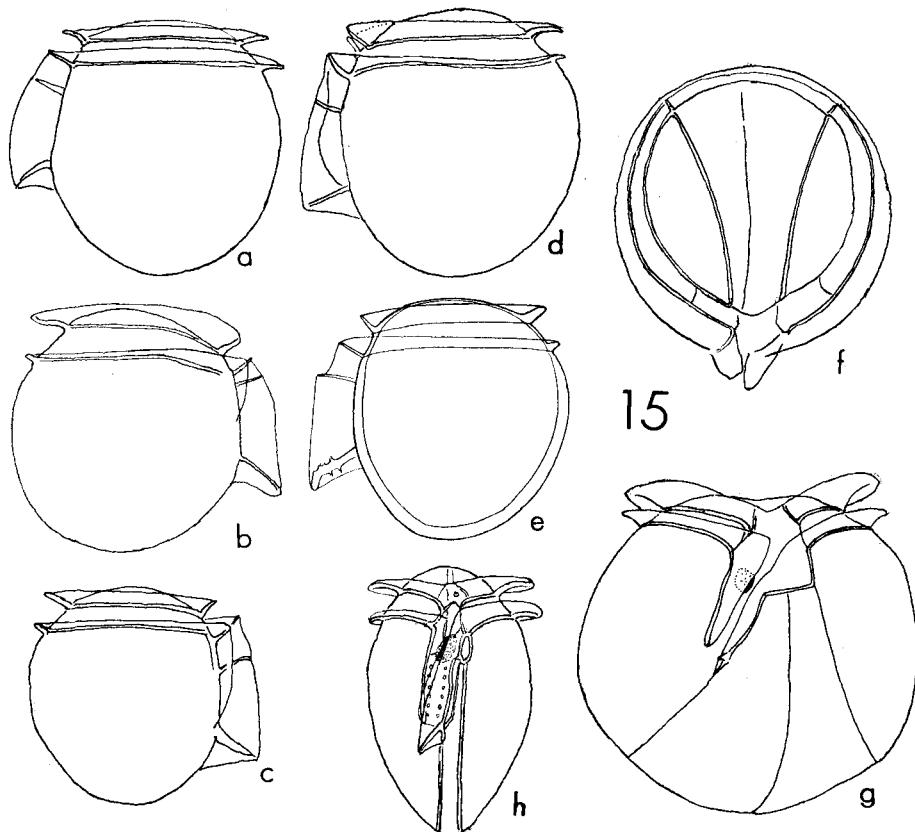


Fig. 15. *Dinophysis rotundata* CLAP. et LACHM. *a-e*, lateral views of five specimens, slightly differing from one another in some points. *h*, ventral view of a specimen with the narrow megacytic zone; the four sulcal plates, the epithecal and hypothecal ventral plates are illustrated. *f*, apical view of a specimen with the megacytic zone broadly built. *g*, ventral view of an extremely megacytic form.

epitheca is convexed as a whole, while in the *g*-specimen there appears a faint but distinct dorso-ventral furrow along the median of the epitheca. The latter is accompanied with a V-shaped inclination of the cingular plain towards the sagittal plane. This can be elucidated, so far as the present author believes, as being induced physically by dint of the uneven growth of the megacytic zone due to lesser plasticity of the

early formed zones of both the epitheca and hypotheca separating the posterior portions of the two valves widely, which induces, in turn, the dorso-ventral furrow on the epitheca.

Dimension: Length, 40–50  $\mu$  (57  $\mu$  in *g*-specimen). Greatest dorso-ventral dimension, 34–45  $\mu$ . Greatest lateral dimension, 25–63  $\mu$  (including the *g*-specimen).

Distribution: Mutsu Bay, Sagami Bay and the Inland Sea of Japan. According to SCHILLER (1931), it was found from all of the European seas. BALECH (1962) recorded this from the middle region of the west coastal waters of South America (27°08' S, 72°02' W).

### *Dinophysis rudgei* (MURRAY & WHITTING)

Fig. 16 a-j.

Syn.: *Phalacroma Rudgei*, PAULSEN, 1908, p. 19, Fig. 22 (after MURRAY & WHITTING): LEBOUR, 1923, p. 78, Fig. 20 e.

*Phalacroma rotundatum*, BERG, 1881, p. 224, Pl. 15, Fig. 55: LEBOUR, 1923, p. 78, Pl. XI, Fig. 3 a-c; SCHILLER, 1931, partim, p. 67, Fig. a-c (after LEBOUR), not *d* (SCHILLER's)

*Dinophysis rotundiformis* TAI & SKOGSBERG, 1934, p. 429, Fig. 2 m.

*Dinophysis rotundata*, PAULSEN, 1908, p. 17, Fig. 18: TAI & SKOGSBERG, 1934, p. 426, Fig. 2 a-l.

*Prodinophysis* cf. *rotundata*, BALECH, 1944, p. 429, Pl. 2, Figs. 7–17.

This species has often been misinterpreted as a megacytic form of *Dinophysis rotundatum* or var. *laevis* (CLAP. & LACHM.) JÖRGENSEN of the same species, but it can be distinguished from those by its larger body size, horizontally expanded cingular lists and more strongly convexed epitheca. The lateral outline of the hypotheca is somewhat longer than broad and evenly rounded nearly all around the body but the antero-dorsal portion (Fig. 16 a-c) where the body bulges out beyond the posterior cingular list. In the ventral view (Fig. 16 d, f, h), the body contour is biconvexed, with an especial bulge at the level of the middle of the body. If Fig. 16 d is compared with Fig. 15 h, the specific distinctiveness of this and the preceding species will be properly understood.

The plate pattern of the ventral area in this species (Fig. 16 d, j) agrees to that shown in Diagram 2 A, just the case is so with Fig. 14 d. The paired ventral epithelial plates are unequal, being arranged obliquely (Fig. 16 d and j). The anterior cingular list is folded, particularly distinctly, along the posterior margin of the smaller right moiety of them as illustrated in Fig. 16 i. The anterior moiety of the ventral hypothecal plates is about one-third as long as the other moiety, and the proximal end of the cingulum bends postero-medianwards in conformity to a slight posterior dislocation of the anterior moiety and also to a short extension of the left larger moiety of the ventral epithelial plates beyond the anterior cingular ridge (Fig. 16 d, j). The total length of the ventral hypothecal plates is about one-half of the dorso-ventral dimension of the epitheca in this species, while that of the preceding species

is about two-thirds. The obliquely truncated posterior end of the ventral area terminates just at or in front of the third rib of the left sulcal list, which represents the posterior extremity of the posterior moiety of the ventral hypothecal plates.

Various stages of megacytic growth were observed. The zone is built along either side of the fission suture subequally in *f*-specimen but unequally in *h*-specimen. In any case, however, the greatest breadth of the zone is usually attained in the

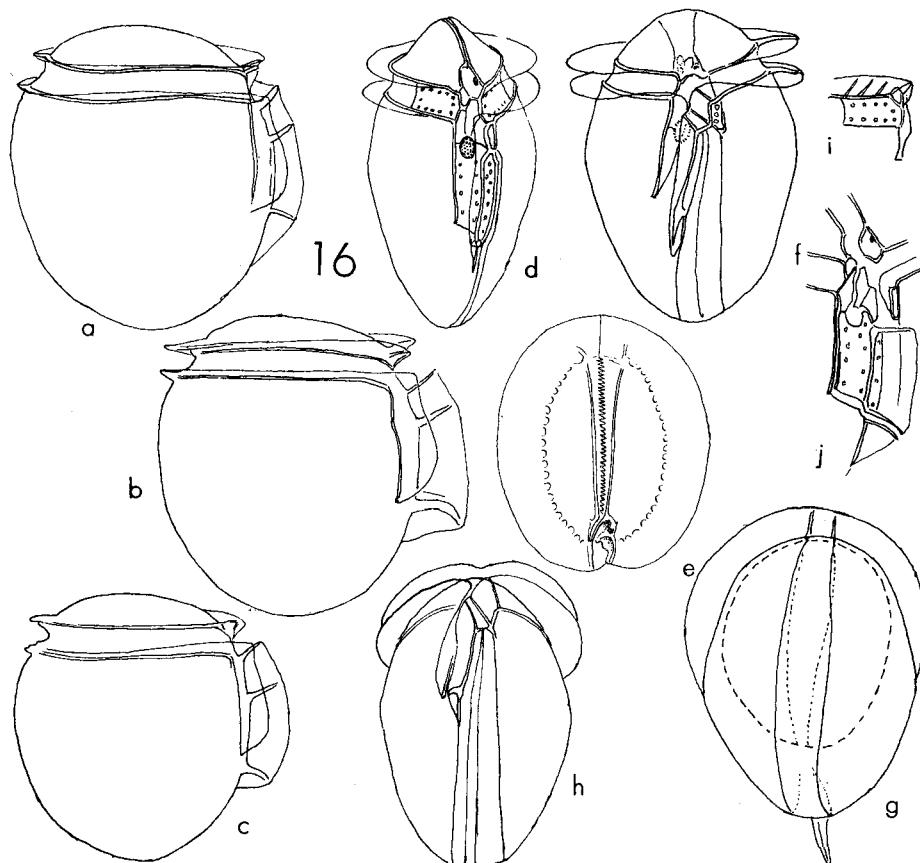


Fig. 16. *Dinophysis rudgei* (MURRAY & WHITTING) and forms. *a-c*, right sides of three specimens, differing in body size and in size and shape of the left sulcal list. *d*, ventral view, showing the sulcal plates and the ventral epithecal and hypothecal plates, together with the ventral cingular plates. *e*, apical view of an isolated epitheca, with the moderately formed megacytic zone. *f*, *h*, ventral and posteroventral views of two moderately grown specimens; the megacytic zone is formed subequally along the fission suture in *f*, but unequally in *h*. *g*, posterodorsal view of a specimen, showing the variable breadth of the megacytic zone. *i* shows the right sulcal plate, the right cingular plate, and the right ventral epithecal plate which is extending posteriorly to the middle of the cingulum to form a pocket-like folding of the anterior cingular list. *j*, the four sulcal plates, the two ventral epithecal plates, and the two ventral hypothecal plates; all are nearly separated from one another, yet in their natural situations.

postero-dorsal region of the hypotheca, as illustrated in Fig. 16 g.

Dimension: Length, 55–65  $\mu$ . Greatest dorso-ventral dimension, 50–59  $\mu$ .

Distribution: Mutsu Bay, Sagami Bay and the Inland Sea of Japan. This was recorded from the subtropical and warm temperate waters both of the Atlantic and the Pacific Ocean and also from the Mediterranean and the Adriatic Sea.

? *Dinophysis porodictyum* (STEIN)

Fig. 17 a-f.

Syn.: ?*Phalacroma porodictyum* STEIN, 1883, Pl. 18, Figs. 11–14; BÜTSCHLI, 1885, Pl. 55, Fig. 1; SCHÜTT, 1895, p. 93, Pl. 2, Fig. 13<sub>1–5</sub>; OKAMURA, 1912, Pl. 5, Fig. 83; JÖRGENSEN, 1923, p. 9, Fig. 6; SCHILLER, 1931, partim, p. 73, Fig. 66 b; KOFOID & SKOGSBERG, 1928, p. 98, Fig. 6<sub>1–5</sub>; BALECH, 1962, p. 126, Fig. 214.

The present specimens seem to agree most closely with OKAMURA's (1912), but not so well to the others' which show variations in some points according to authors. Moreover, no one has ever presented finer and detailed morphological features of this and allied species. Consequently the specific name *porodictyum* here presented to the present specimens is to be accepted as provisional. The present author is going to describe and figure some morphological details of this form for the purpose of presenting here some of newly uncovered morphological features and in a hope of eliminating difficulties in further diagnoses of the species.

The thecal wall flares most strongly along the cingular ridges. The epitheca in both of the lateral and the dorso-ventral outlines is moderately convexed as a whole, its maximal height is about one-third of the dorso-ventral dimension. The hypotheca is about two-thirds as long as its dorso-ventral dimension and, in its lateral outline, moderately and fairly evenly rounded nearly all around but its antero-ventral portion along the ventral area, where the body contour is fairly straight, keeping an angle of 110° between this and the cingular plain. The ventral area occupies the anterior 0.4 of the hypotheca in length, though this value slightly varies according to different megacytic stages.

The megacytic zone in the epitheca invariably increases the breadth dorsally, and in the ventral half of the hypotheca but in the dorsal half the zone keeps a constant breadth throughout the entire length or it increases its breadth very slightly towards the dorsal portion of the cingulum (Fig. 17 c, d, e,). Lateral halves of the broad megacytic zone are differentiated respectively into more than two longitudinal stripes showing different grades of reticulation which is fading away towards the fission suture in some distinctive grades. This seems to show undoubtedly the possibility that the zone formation occurs intermittently being affected directly or indirectly by chemical and physical conditions of the ambient water, or by the physiological periodicity of the organism itself.

The paired ventral epithelial plates are unequal in size, taking somewhat lateral

arrangement in the majority of specimens observed (Fig. 17 c) because of the general formation of the megacytic zone of a considerable breadth, but in extreme megacytic stages their lateral dimension is so great as to conform to the considerable growth of the megacytic zone (Fig. 17 f). The left moiety of them in these specimens seems superficially to consist of a dorsal and a ventral element, though further analyses have proved that there is found a unified platelet. The paired ventral hypotheca plates are subequal in length and show individual variations in their breadth (Fig. 17 c, f). The breadth of their posterior moiety in Fig. f, is seemingly

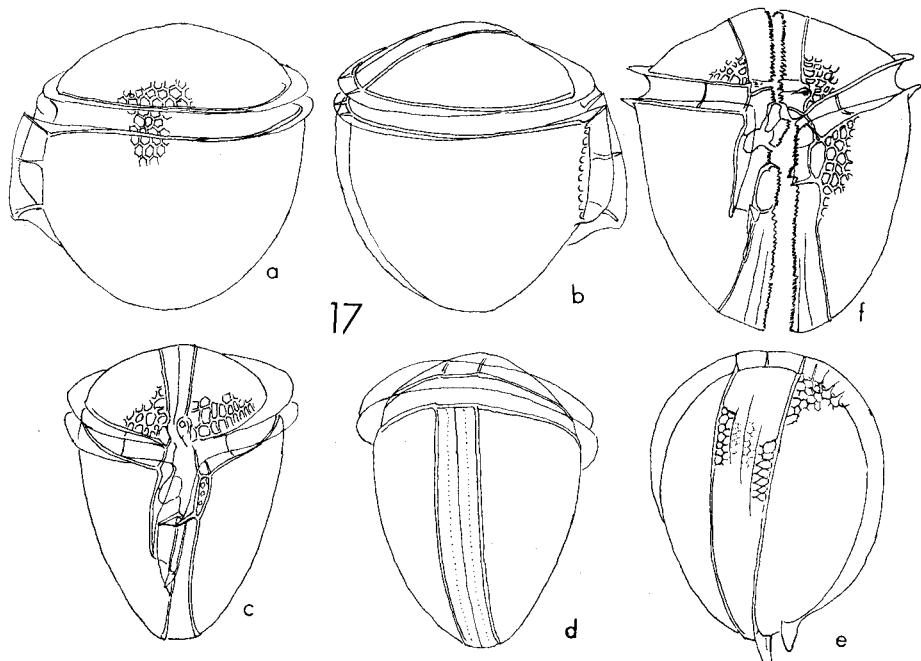


Fig. 17. *Dinophysis porodictyum* (STEIN). a, leftside. b, rightside. c, ventral view. d, dorsal view. e, antapical view of a specimen the broad megacytic zone which can be subdivided into four stripes marked respectively with the meshwork of different distinctness. f, ventral view of a partly dissociated specimen, showing the two direction routes of the growth or the megacytic zone within the sulcus.

increased by the additive formation of the megacytic zone, but its anterior moiety of the same individual is a little broader, too, as compared with that of Fig. c. Fig. 17 f represents an interesting example to show branched routes of the growth zone within the ventral area. A broad megacytic zone is seen along the median side of both the left ventral cingular plate and the anterior moiety of the ventral hypothecal plates. Along the median margins of these plates one can discern the serrated structure, characteristic of the sagittal suture only. Just the same structure is seen along the left sides of the right sulcal and the anterior left arm of the posterior sulcal

plate. In this respect, it is to be noticed that the megacytic zone built along the anterior ventral hypothecal plate forms a small extension by which the plate is brought into contact with the posterior sulcal plate. This is of utmost significance in solving the question of the unproportional breadth increase of the right sulcal plate, which can be easily noted by comparing Fig. 17 *f* with Fig. 16 *j*. Basing on the above-mentioned morphology one can conclude that the growth zone within the ventral area comes to bifurcate anteriorly just in front of the fission rib; one branch running straight anteriorly along the left side of the sulcal group of plates, while the other passing obliquely across the flagellar pore towards the median brim of the right sulcal plate. It may be worthy to note the fact that only the anterior sulcal plate is the stable sulcal element throughout the megacytic growth.

Dimension: Length, 80  $\mu$ . Greatest dorso-ventral dimension, 70  $\mu$ . Greatest lateral dimension, 60–65  $\mu$ .

Distribution: Sagami Bay. In all probability, in the tropical and subtropical to the temperate waters of the Pacific and the Atlantic, and also the Mediterranean Sea.

#### *Dinophysis mitra* (SCHÜTT)

Fig. 18 a-q.

Syn.: *Phalacroma mitra* SCHÜTT 1895, Pl. 4, Fig. 18<sub>1-4</sub>; OKAMURA, 1912, Pl. 5, Figs. 78–80; PAVILLARD 1916, p. 53, Figs. 13 *b*, 14 *a-c*; FORTI, 1922, p. 105, Pl. 7, Fig. 109; OLMANS, 1922, p. 54, Fig. 38 *b, c*; ABE, 1927, p. 385, Fig. 3 *a-f*; SCHILLER, 1931, p. 90, partim, Fig. 82; GAADER, 1954, p. 53.

*Phalacroma rapa* STEIN, 1883, p. 23, Pl. 19, Figs. 5–8; BÜTSCHLI, 1885, Pl. 55, Fig. 2; PAVILLARD, 1916, p. 47, Fig. 13 *a*; FORTI, 1922, p. 107, Fig. 113; JÖRGENSEN, 1923, p. 14, Fig. 14.

*Phalacroma dolichopterygium*, JÖRGENSEN, 1923, p. 15, Fig. 15; SCHILLER, 1931, P. 90, Fig. 81.

*Phalacroma* sp., OKAMURA, 1907, partim, p. 134, Pl. 5, Fig. 42 *a*, (not *b*).

CLEVE (1901) considered *Dinophysis mitra* and *Dinophysis rapa* as identical with each other, and also PAVILLARD (1916) and JÖRGENSEN (1923) held their specific separation as questionable. Similar discussions have often been offered by various authors. For the purpose of answering this question, the present author is going to present here the details of the morphological variations brought forth by the megacytic growth.

The *a* and *b* of Fig. 18 represent respectively the lateral and the dorsal outline of the same specimen just after the binary fission, so judged because of the existence of the unabsorbed remnant of the megacytic zone at the antapical end. In the *c-d* specimen, no remnant remains, but the megacytic zone is not as yet formed. On the contrary, in the *k-l* specimen the megacytic zone is attained to its greatest breadth subequal to the greatest lateral dimension of the original body of the *a-b* specimen. The *f-g* and *i-j* specimens represent respectively different intermediate stages of the megacytic growth. Reviewing these, one will notice the fact that in

accord with the progressive growth of the megacytic zone the postero-ventral concavity of the hypotheca becomes much less distinct and the posterior end of the body becomes more rounded, while the cingular plane and the straight antero-ventral side of the hypotheca are kept unchanged throughout the stages crossing each other at the angle of 110–120°. Basing on these, the present author concludes here that all the specimens cited here form a single distinct species, *Dinophysis mitra*.

The *p*-specimen of Fig. 18 is undoubtedly one of the extremely advanced mega-

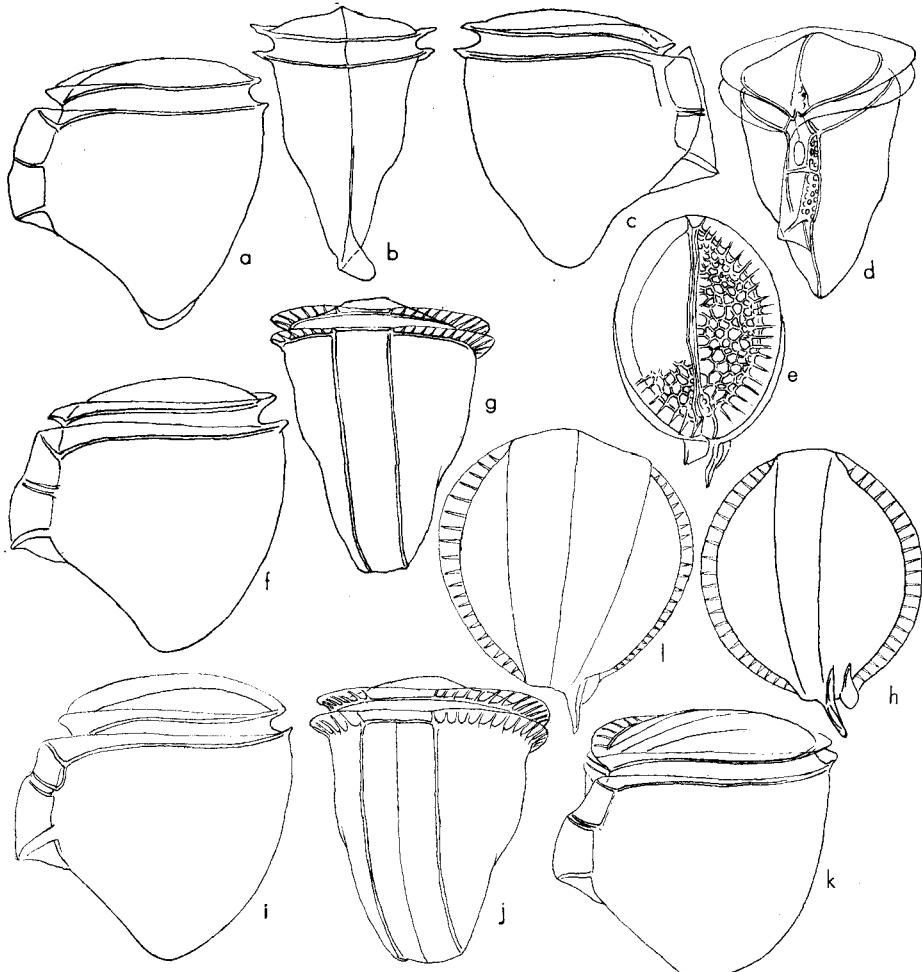


Fig. 18–1. *Dinophysis mitra* (SCHÜTT). *a, b*, side and dorsal views of a specimen in the stage just after binary fission. *c, d, e*, side, ventral and apical views of a specimen in which the subsutural growth is just to be started. *f, g, h*, side, dorsal and antapical views of a specimen with the growth zone of a considerable breadth. *i* and *j*, a specimen with the broader growth zone. *k, l*, a further grown specimen with the greatest megacytic zone nearly as wide as the greatest lateral dimension of the *a-b* specimen.

cytic stages, in which the greatest breadth of the body is attained more than 1.5 times that of the *a-b* specimen and the body contour in ventral view is nearly rectangular, or rather pentagonal, in stead of being triangular. The megacytic zone keeps, throughout the growing stages, a fairly constant breadth along the entire dorsal length

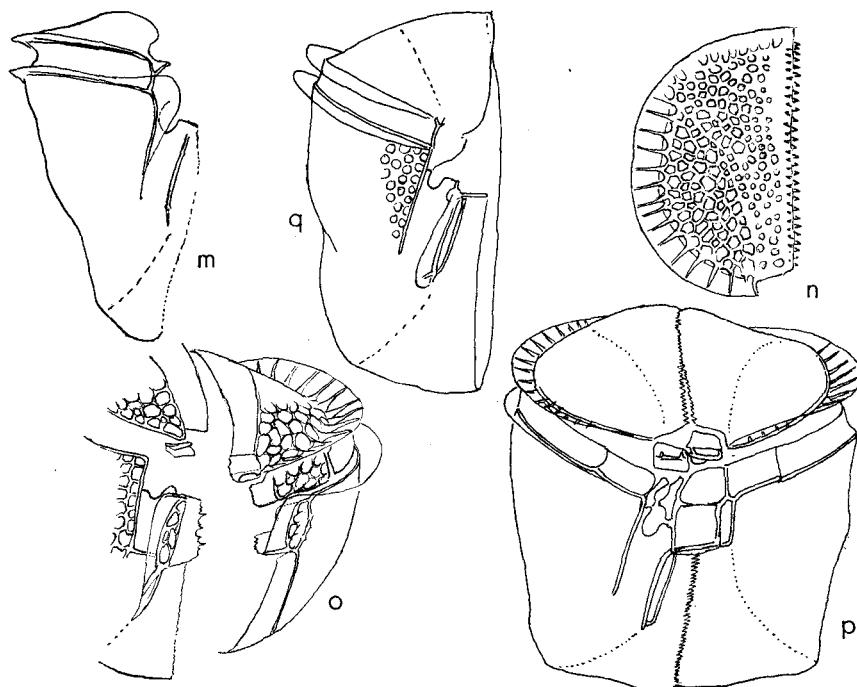


Fig. 18-2. *Dinophysis mitra* (SCHÜTT). *m*, ventral view of an isolated right valve, somewhat compressed dorsoventrally. V-shaped folding of the anterior cingular list at its ventro-median end to fit the right ventral epithelial plate, can clearly be seen. *n*, an apical view of the isolated overgrown right dorsal epithelial plate of a rather small specimen, in which the border between the original area and the additional grown area is made obscure by newly formed meshworks of the thecal wall. *o*, partially dissociated ventral portion of a fairly well grown specimen in which the zone of megacytic growth can be distinguished along the median margins of the left ventral cingular plate and the anterior moiety of the paired ventral hypothecal plates. *p*, ventral view of an overgrown specimen in which a broad megacytic zone is subequal in width with the old sulcus itself, passing longitudinally between the epitheca and the split fission rib. This consists anteriorly of medianward outgrowth of the ventral cingular plate and posteriorly of the anterior moiety of the paired ventral hypothecal plate. Breadth of the two ventral hypothecal plates remains unchanged, but they are separated laterally by the breadth of the megacytic zone at this portion. It is to be noted that the two ventral epithelial plates have subequally an unusually remarkable breadth. In consequence, the megacytic growth zone of this specimen is formed around the body without any structural relationship with the flagellar pore just as the case with *Heteroschisma aequale* KOROID (1928, pl. 1, fig. 7), in which the extremely broad megacytic zone does not pass across the sulcus. In *Phalacroma porosum* KOROID and MICHNER (KOROID 1928, pl. 1, fig. 3), however, it is shown as if the broad megacytic zone passes through the anterior half of the sulcus just as in the present specimen.

of the hypotheca (Fig. 18 *g, j*), but shows a gradual increase in breadth on the ventral and the dorsal of the zone is built invariably so as to form distinct demarcations along the border between the original area of the thecal valve and the newly built megacytic zone. On the contrary, in the epitheca the megacytic zone is built in the main in conformity to the original curvature of the epithecal plate (Fig. 18 *j, m-q*). When the isolated right valve of a specimen with the moderately grown megacytic zone is lightly pressed in the dorso-ventral direction (Fig. 18 *m*), the hypothecal portion of the megacytic zone will yield some deformation. However, when the disjoined right valve of overgrown specimen is pressed in the same way (Fig. 18 *q*), the ridge formed in the hypotheca will remain scarcely deformed. In the epitheca, both of the original epithecal portion and the additionally built growth zone are areolated as shown in Fig. 18 *n*, the original median boundary of the plate being disappeared, and form together a uniformly curved surface. The areolation and the rib-formation of the cingular list seen within the megacytic zone are somewhat irregular and this indicates the progressive reorganization of the structural differentiation of the thecal wall (ref. fig. *c*).

In extreme cases, the megacytic zone is built unusually along the median sides of the paired ventral epithecal plates as illustrated in Fig. 18 *o* and *p*, but it is to be noticed that the zone within the ventral area runs, peculiarly enough, along the left of the sulcal group of plates, clearly indicating that the zone is built as the median-ward extensions of both the left ventral cingular and the anterior ventral hypothecal plates in the *p*-specimen, just as the case seen in Fig. 17 *f*. It is not certain, however, whether or not such a route of the megacytic zone within the ventral area is normal. It is strange, however, extremely advanced megacytic forms as the *p*-specimen have been found most frequently in Mutsu Bay, the faunistical peculiarity of which shall be discussed in one of forthcoming papers.

Dimension: Length, 63–72  $\mu$ . Greatest dorsoventral dimension, 50–58  $\mu$ .

Distribution: Mutsu Bay, Sagami Bay, the Inland Sea of Japan. Very widely distributed in the temperate warm waters of the Atlantic, the Mediterranean Sea and the Pacific.

#### *Dinophysis rapa* (STEIN)

Fig. 19.

Syn.: *Phalacroma rapa*, JÖRGENSEN, 1923, p. 14, Fig. 14: KOFOID & SKOGSBERG, 1928, p. 139, Fig. 16: KOFOID & SKOGSBERG, 1931, partim, p. 139, Fig. 89 a, b, d (c is questionable).  
*Phalacroma mitra*, OKAMURA, 1907, p. 134, pl. 5, Fig. 43.

In characterizing this species, the present author agrees in the main with KOFOID & SKOGSBERG. The left side of the ventral area is more strongly protuberant than its right side, and this left side ridge is so strongly slanting as to make an angle of 120° between it and the cingular plane. In addition, the ventral side of the lateral

outline of the hypotheca shows a distinct concavity just posterior to the rear end of the sulcus. These structural peculiarities are never established in any species previously described.

Dimension: Length 80  $\mu$  or more. The greatest dorsoventral dimension ca. 70  $\mu$ .

Distribution: Sagami Bay. The temperate warm waters of both the Pacific and the Atlantic.

*Dinophysis favus* (KOFOID & MICHENER)

Fig. 20 a-c.

Syn.: *Phalacroma favus* KOFOID & MICHENER 1911, p. 289; JÖRGENSEN, 1923, p. 15, Fig. 16; KOFOID & SKOGSBERG, 1928, p. 146, Fig. 14<sub>4,5</sub>, Pl. 2, Fig. 7; SCHILLER, 1931, p. 91, Fig. 83 (after KOF. & SKOGSBG.); WOOD, 1953, p. 15, Fig. 16.

Larger and smaller forms can be distinguished in this species. In both of them,

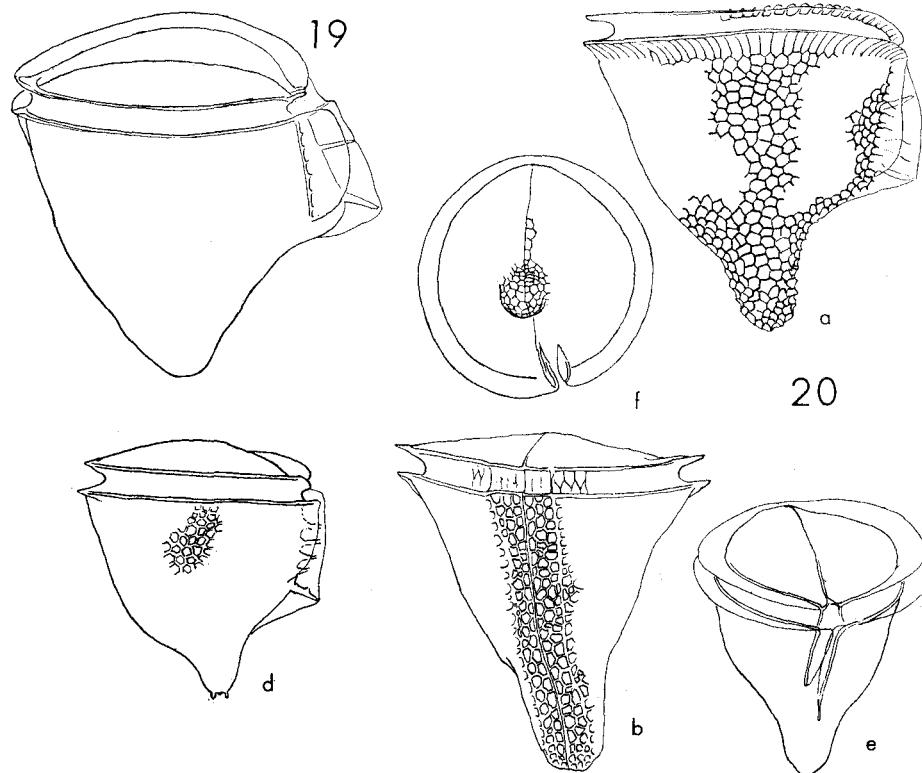


Fig. 19. *Dinophysis rapa* (STEIN)

Fig. 20. *Dinophysis favus* (KOF. & SKOGSBG.) a, b, right side and dorsal view of a larger specimen with the growth zone of a considerable width. d, e, f, right side, ventral and apical views of a smaller form.

the antapical finger-shaped protuberance can be discerned not only in the lateral view but also in the dorso-ventral view, further even in the antapical view of the body. For this character, this form apparently deserves a distinctive species regardless of questions frequently presented.

Dimension: Length,  $60-65\mu$  in the smaller and  $85\mu$  or a little more in the larger form. The greatest dorso-ventral dimension  $60\mu$  in the smaller and  $80\mu$  in the larger form.

Distribution: Sagami Bay. From the oceanic areas of the tropical, subtropical and the temperate seas.

*Dinophysis cuneus* (SCHÜTT)

Fig. 21 a-h.

Syn.: *Phalacroma cuneus* SCHÜTT, 1895, p. 148. Pl. 3, Fig. 14: OKAMURA, 1912, p. 18, Fig. 76: JÖRGENSEN, 1923, p. 11, Fig. 11: KOFOID & SKOOGSBERG, 1928, p. 124, Fig. 12<sub>1-3</sub>: SCHILLER, 1931, p. 84, Fig. 76 a-c (not d): WOOD, p 187, 1953, Fig. 20 a, b.  
*Phalacroma triangulare* WOOD, 1953, p. 187, Fig. 21.

The thecal wall flares very distinctly along the cingular edges and is moderately convexed as a whole in the epitheca. In apical or antapical view, the epitheca is broad elliptical with its dorso-ventral dimension 1.2 times the lateral dimension. In side view, the thecal outline of the hypotheca is sigmoid, very weakly along the dorsal, moderately along the ventral, and most prominently along the lateral sides. The posterior half of the hypotheca is gently rounded in lateral outline, but narrowed more or less sharply in a wedge shape in dorso-ventral outline. The actual posterior extremity of the hypotheca is dislocated, though very slightly, to the ventral of the middle of the body.

The ventral epithecal plates and ventral portions of the dorsal epithecal plates of a specimen in their intact situations are shown in Fig. 21 f, and the ventral portion of the left half of the epitheca isolated from another specimen is shown in Fig. 21 h and disjoined four epithecal plates are given in Fig. 21 g. From these figures, one can learn that the left ventral epithecal is two- or three-times larger than the right ventral which corresponds in size to a single mesh of the reticulation on the theca and both plates are furnished each with a small part of the list along their ventral edges, and that the so-called epithecal pore is nothing but a small slit left open between the left ventral and dorsal epithecal plates because of the existence of a small dent on the lateral side of the left ventral epithecal plate. The way in which the list of the right ventral moiety concerns the formation of a pocket-like folding of the anterior cingular list is shown in Fig. 21 e. A slight postero-medianward bending of the proximal end of the cingulum and the posteriorward dislocation of the anterior moiety or rather both of the hypothecal ventral plates are discernible in Fig. 21 b and e, or these may be understood from the shape of the isolated left ventral cingular plate (Fig. 21 f).

The ventral area is obliquely truncated posteriorly and terminating at the base of the third rib of the left sulcal list (Fig. 21 *b, e*).

Dimension: Length, 95  $\mu$ . Greatest dorso-ventral dimension, 105  $\mu$ . Greatest lateral dimension, 90  $\mu$ .

Distribution: Mutsu Bay. Records from wide tropical, subtropical and warm temperate areas in the Pacific, the Atlantic and the Indian Ocean.

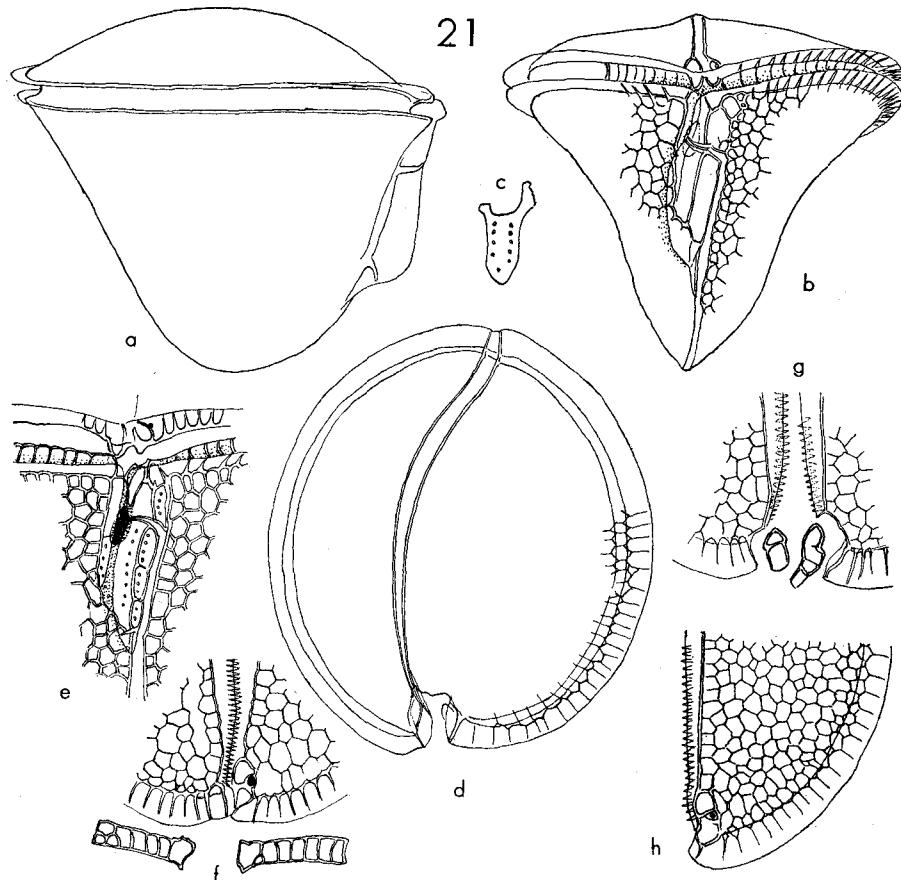


Fig. 21. *Dinophysis cuneus* (Schütt). *a, b, d*, leftside, ventral and antapical views of the same single specimen. *c*, posterior sulcal plate. *e*, ventral view of the sulcus and its surrounding. *f*, ventromedian portion of the epitheca and the ventral cingular plates. *g*, ventromedian portion of the epitheca; the four epithecal plates are separated from one another and the characteristic serration is shown along the sagittal suture. *h*, the ventral half of the left epithecal plates, the ventral and the dorsal epithecal plates are not disjoined.

*Dinophysis acutum* (SCHÜTT) PAVILLARD

Fig. 22 a-k.

Syn.: *Phalacroma acutum* (SCHÜTT) PAVILLARD, 1916, p. 55, Pl. 3, Fig. 7; JÖRGENSEN, 1923, p. 10, Fig. 8; SCHILLER, 1928, p. 71; 1931, p. 87, Fig. 79 a (after SCHÜTT).

The body in lateral outline is somewhat broad ovate or rather rounded triangular, with the moderately rounded epitheca occupying anterior one-fourth of the body.

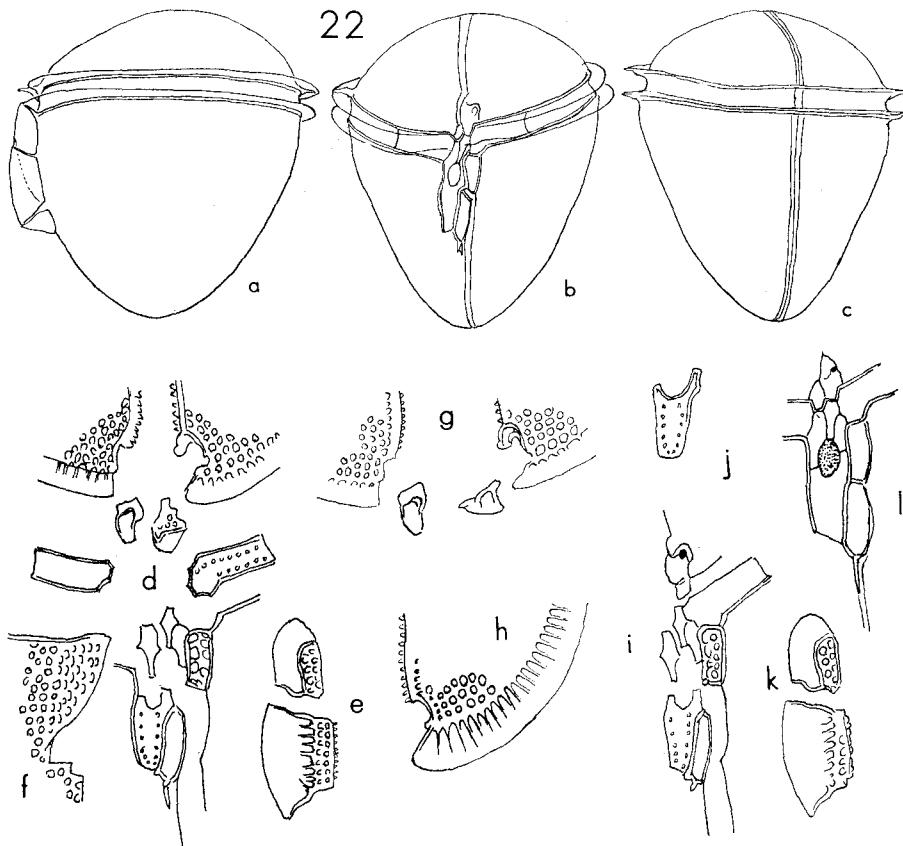


Fig. 22. *Dinophysis acutum* (SCHÜTT) PAVILLARD. *a, b, c*, leftside, ventral and dorsal views of an entire organism. *d*, isolated sulcal and its surrounding thecal plates separated and rearranged in their natural situations. *e*, isolated two ventral hypothecal plates, with their median lists. *f*, anteromedian corner of the right dorsal hypothecal plate, showing the triangular right sulcal list and two notches respectively fitting the posterior end of the posterior sulcal plate and that of the posterior moiety of the ventral hypothecal plates. *g*, two ventral epithecal plates, isolated from the two dorsal epithecal plates. *h*, ventral end of the left dorsal epithecal plate, deprived of the left ventral epithecal plate. *i*, the sulcal plates and their surrounding of another specimen (*i-k*) else than the specimen shown in *d*. *j*, isolated posterior sulcal plate. *k*, isolated two ventral hypothecal plates and their lists, corresponding to *e*, but derived from another specimen, proving their least variability. *l*, schematically reconstructed plate-pattern in and around the sulcus.

The hypotheca is more elongated and occupies posterior 0.7 of the body; it is contracting posteriorly, with weakly rounded dorsal and ventral margins and rather acutely rounded antapical end. So far as these features are concerned, this species appears to be near akin to *Phalacroma* (= *Dinophysis*) *ovum* of KOFOID & SKOGSBERG's (1928, Fig. 11<sub>1,3-4</sub>), but the former is more rotund than the latter. In addition, the former differs from the latter in the shape, height and the basal length of the left sulcal list. There has not been recorded any species of this form group, worthy to be discussed here, with the exception of *Phalacroma acuta* (SCHÜTT).

The present author's morphological analyses were concentrated on the ventral area and its surrounding region. The plate pattern of this region is illustrated schematically in Fig. 22 *l*. The disjoined ventral epithecal plates and ventral portions of the dorsal epithecal plates are illustrated in Fig. 22 *d* and *g*, respectively derived from different specimens. It may be worthy to draw attention that a peculiarly curved small projection of the left dorsal epithecal plate, is extending around the dorsal and median margins of the epithecal pore. The dorsal half of the pore-rim is seen fairly clearly in Fig. 22 *g*, but not at all in Fig. 22 *d*. This projection is lost in the preparation shown in Fig. 22 *h*. The present author could not ascertain, however, whether or not this small projection represents a distinct platelet. Posteriorward bending of the proximal end of the cingulum can clearly be seen in Fig. 22 *b*, *d* and *i*. The ventral hypothecal plates with or without their lists are illustrated in Fig. 22 *d*, *e*, *i* and *k*; all these preparations were derived from different specimens, but they invariably agree with one another in the shape and relative length of these plates. Of the sulcal elements, the posterior plate exhibits a range of variation in the length of its anterolateral extensions. Fig. 22 *f* represents the antero-ventral portion of the right dorsal hypothecal plate together with the right sulcal list. Just below the posterior end of the list, the plate is deeply notched to form there two step-like indents; the anterior stair accommodating to the posterior end of the posterior sulcal plate and the posterior stair to the rear end of the posterior ventral hypothecal plate.

Dimension: Length, 65–70  $\mu$ . Greatest dorso-ventral dimension 56–60  $\mu$ .

Locality: Mutsu Bay. Reported from the Mediterranean Sea and the Atlantic Gulf Stream.

#### *Dinophysis argus* (STEIN)

Fig. 23 a, b.

Syn.: *Phalacroma argus* STEIN, 1883, Figs. 15–17: SCHÜTT, 1895, p. 13, Pl. 3, Fig. 15<sub>1-3</sub>: JÖRGENSEN, 1923, 13, Fig. 13: KOFOID & SKOGSBERG, 1928, p. 104, Fig. 8<sub>1-3</sub>: SCHILLER, 1931, p. 74, Fig. 67 a (after KOF. & SKOGSBG.): WOOD, 1953, partim, p. 186, Fig. 16 b (not a): BALECH, 1962, p. 126.

The epitheca is prominently convex, occupying anterior 0.3 of the body and

rounded triangular in lateral outline. Its height or length is 0.32 of the dorso-ventral dimension of the body. The hypotheca, occupying 0.73 of the body length, is a little longer than broad in lateral outline, with length/breadth ratio 1.4. In lateral outline, the hypotheca of this species closely resembles that of *Dinophysis*

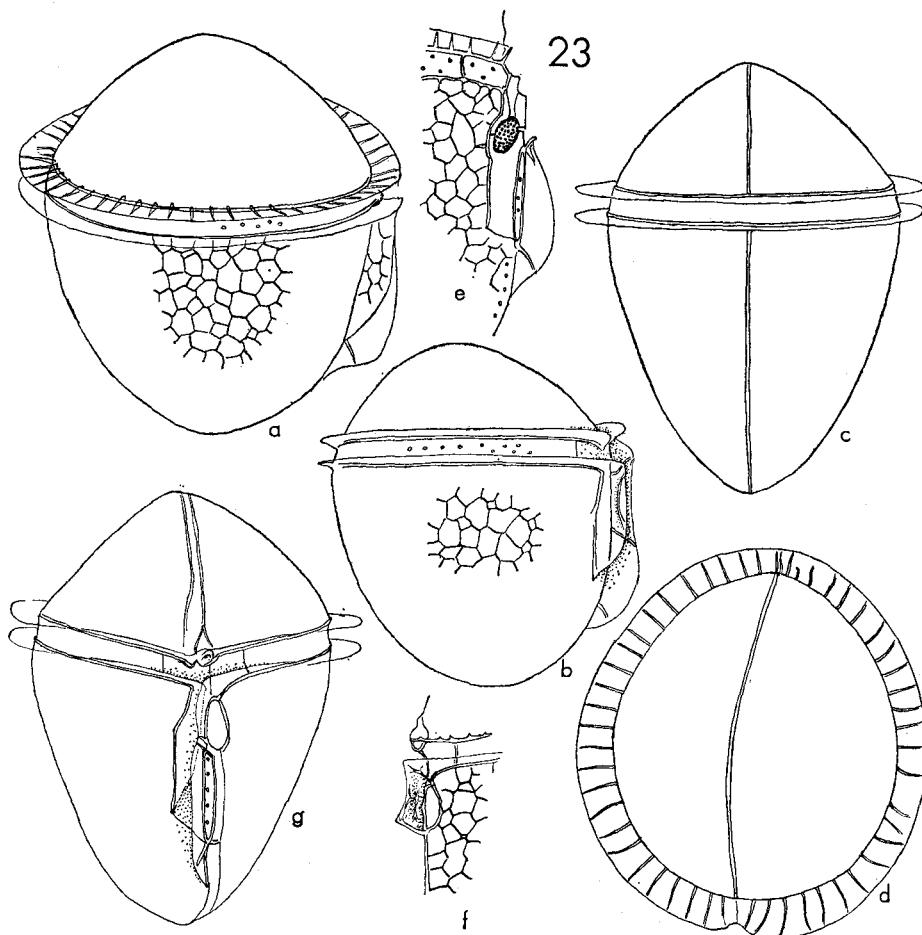


Fig. 23 a-b. *Dinophysis argus* (STEIN).

c-g. *Dinophysis apicalum* (KOF. & SKOGSBG). c, d, g, dorsal, apical and ventral views of an entire organism. e, f, the sulcus and its surrounding, splitted into two lateral plate-groups.

*porodictyum* (Fig. 17 a, b), but the specific distinctiveness of these two species may in all probability be proved by a clear difference found in the structure of the sulcal list. In the present species the basal length of the list corresponds to 0.75 of the hypothecal length, while the ratio is 0.6 in *D. porodictyum*. The ventral area is absolutely and also relatively longer in the former than in the latter: the structure

occupies in the former anterior 0.6 of the hypotheca, while 0.4 in the latter.

Dimension: Length, 81–95  $\mu$ . Greatest dorso-ventral dimension, 67–80  $\mu$ .

Distribution: Sagami Bay. Widely distributed in the tropical, subtropical and the warm temperate seas.

*Dinophysis apicatum* (KOFOID & SKOGSBERG)

Fig. 23 c-g.

Syn.: *Phalacroma apicatum* KOFOID & SKOGSBERG, 1928, p. 111, Fig. 10<sub>1–5</sub>: SCHILLER, 1931, p. 76, Fig. 68 (after KOFOID & SKOGSBERG): BALECH, 1962, p. 129.

The present specimens collected from Shimoda Bay agree in the main with KOFOID & SKOGSBERG's. However, in regard to the structural relations of the sulcal lists, KOFOID & SKOGSBERG seem to have made some misinterpretation, as the present specimens agree in this respect with *Dinophysis argus* illustrated in Fig. 23 a and b. According to KOFOID & SKOGSBERG (1928, p. 104–106), "the right sulcal list—in some, does not quite extend to the ventral margin of the left sulcal list, but in others it does. The anterior half to two thirds of the free margin of this is more or less concave and, at least in some specimens, is strengthened by a marginal rib; the posterior portion of this margin, which forms a distinct angle with the anterior portion, is more or less convex or seldom, almost straight. The great width of this list is located just behind the concave portion."

This SKOGSBERG's description of the structural peculiarity of the sulcal lists is apparently based on MICHENER's misdrawings so far as judged from KOFOID's description (KOFOID & SKOGSBERG, 1928, pp. 15–16) that "The original drawings and records of occurrences based on the painstaking examination of the plankton collections are the work of Mrs. MICHENER from May 1905 to June 1908, and from June 1909 to July 1910. Her sketches have been utilized in the text figures and her detailed drawings, finished in pencil, have been transferred and prepared for reproduction—", and further KOFOID mentioned that "The manuscript of Part I, Systematic Account, of this work has in the main been prepared by Dr. SKOGSBERG, with the continuous collaboration and joint analysis of all moot points with the senior author." The structural peculiarities of the sulcal lists were given in similar way for *Phalacroma porodictyum* (Fig. 5), *Phalacroma argus* (Fig. 8) and *Phalacroma apicatum* (Fig. 10). The peculiarities of the preceding species (Fig. 23 b) and the present species agree well with that roughly illustrated by the American authors. So far as the present author's analyses uncovered, the peculiarity is not exhibited in the right sulcal list but apparently due to the structural differentiation in the anterior half of the left sulcal list. The list is distinctly undulating, and strongly convexed towards the lateral in its basal half, while it is concave towards the lateral in its distal part so that there must be within the anterior portion of the left sulcal list a narrow longitudinal zone along which the curvature of the list is abruptly converted reversely, and this zone is seen in

lateral view as a concaved line. If this structural peculiarity is overlooked, one may repeat the misinterpretation ever done by KOFOID and MICHENER. This undulating structure was established by separating the anterior half of the list from the posterior half (Fig. 23 f). The ventral area and its surrounding portions are illustrated in Fig. 23 e and f. The right valve is slightly compressed, so that the posterior major portion of the list is forced to bend somewhat leftwards, and the right ventral epithecal plate is lost (e). While, the left valve is much less compressed and the anterior portion of the sulcal left is inclined rightwards (f). In connection with these, it is to be noted that the right sulcal list and the anterior portion of the left sulcal list are reticulated, though irregularly and faintly. The posterior end of the sulcus is variously truncated, terminating regularly at the third rib of the left sulcal list.

Dimension: Length, 93–108  $\mu$ . Greatest dorso-ventral dimension, 80–85  $\mu$ . Greatest lateral dimension, 75–84  $\mu$ .

Distribution: Shimoda Bay. This was recorded by KOFOID and SKOGSBERG from the far offshore waters of the East Pacific and by OKAMURA (1907) from the offshore waters of the province Tosa of Shikoku. The former authors suggested that this species might be eupelagic and OKAMURA's specimens might be "probably eupelagic". As pointed out already in the present author's previous paper (1966), a powerful branch of the Kuroshio flows into Sagami Bay and circulates anti-clockwise. In addition, the up-welling become frequently very prominent at high tide near the mouth of Shimoda Bay.

#### *Dinophysis elongatum* (JÖRGENSEN)

Fig. 24 a-f.

Syn.: *Phalacroma elongatum* JÖRGENSEN, 1923, p. 10, Fig. 9: PAVILLARD, 1923, Fig. 1: SCHILLER, 1931, p. 82, Fig. 75 a: WOOD, 1953, p. 10, Fig. 9: GAARDER, 1954, p. 51, Fig. 67 a, b.  
*?Phalacroma lacrima* GAARDER, 1954, p. 52, Fig. 68 a-c.

There has not been reported any about the thecal morphology of this extremely rare small and hyaline species.

A single specimen was collected from Shimoda Bay in November of 1936. This exhibits an incomparable peculiarity of forming the megacytic zone only along the median margin of the right valve. In spite of such asymmetry, the epitheca is bilaterally symmetrical in ventral outline with the median fission suture dividing the epitheca into two equal halves, though the megacytic zone is lying only along the right of the fission suture. On the contrary, the posterior end of the hypotheca is obliquely truncated owing to the formation of the megacytic zone limited on one side (Fig. 24 a). The larger left and the smaller right epithecal ventral plates are arranged somewhat diagonally, and both of the ventral cingular plates are similarly a little longer than broad.

In lateral view, the left sulcal list appears to bear a single rib at its postero-median point. Closer examinations, however, revealed the existence of the third rib at a short distance from the second rib. The width of the ventral hypothecal plates is so small that they can hardly be discerned in ventral view of the body. The actual existence of these plates was, however, ascertained by separating the thecal wall into constitutional elements. The smaller posterior moiety of them, together with its list, is seen slightly separated from the right dorsal hypothecal plate in Fig. 24 *e*. One may see along the antero-ventral portion of the median brim of the isolated left half

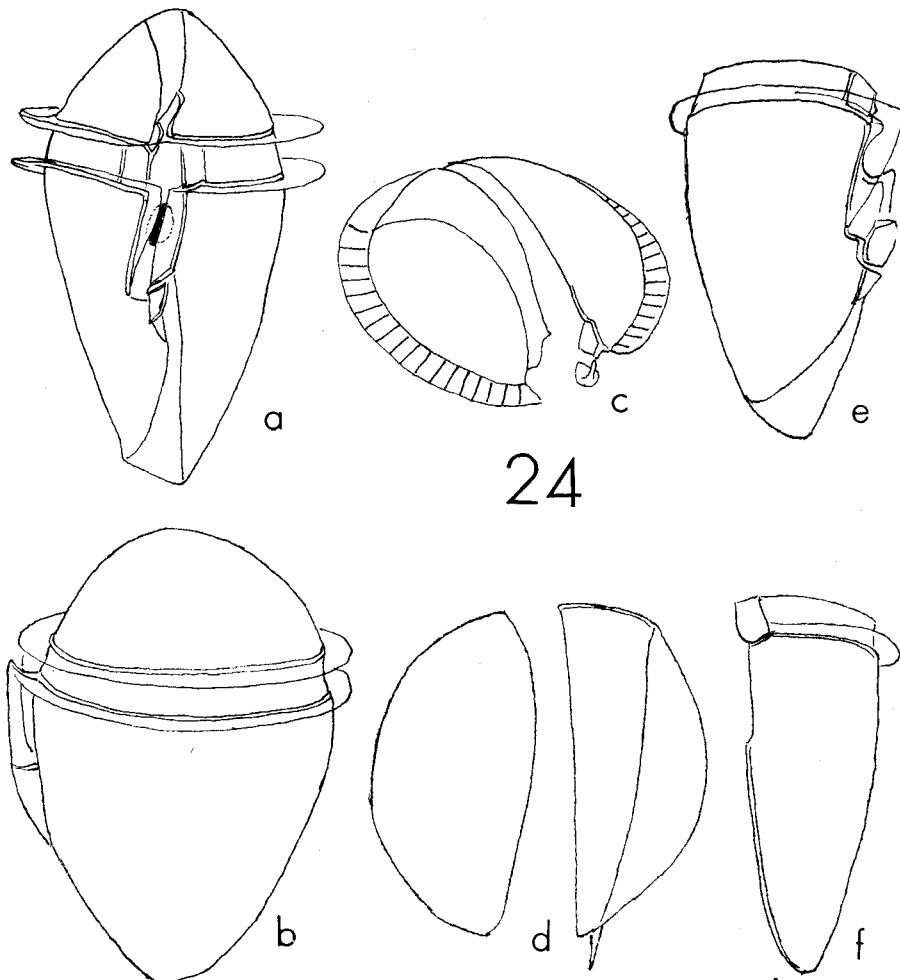


Fig. 24. *Dinophysis elongatum* (JØRGENSEN). *a*, ventral view. *b*, left side. *c*, partially disjoined lateral halves of an epitheca. *d*, antapical view of disjoined lateral halves, the broad growth zone is formed only along one of them. *e*, oblique ventral view of the right half of a hypotheca with the cingulum, deprived of the ventral hypothecal plates. *f*, ventral view of the left half of the hypotheca, with two cingular plates.

of the hypotheca the trace of the detached anterior ventral hypothecal plate as illustrated in Fig. 24 f. The length of this trace agrees exactly with the distance between the first and the second ribs easily observable, suggesting the actual length of the anterior moiety of the paired ventral hypothecal plates. In this respect, it is interesting that PAVILLARD's (1923) figure shows the deficiency of the anterior larger part of the left sulcal list on the one hand and the existence of a rib at a postmedian level of the remained posterior part of the list on the other hand. Judging from these, it is suggestible that his figure represents either the isolated right valve or the right-hand daughter cell just after the binary fission.

Dimension: Length,  $68\mu$ . Greatest dorso-ventral dimension,  $43\mu$ . Greatest lateral dimension,  $34\mu$ .

Distribution: The Mediterranean Sea, north off Spain, off the north-west coast of Africa, north off the Azores, and Sagami Bay, in the north-western North Pacific.

*Dinophysis hastata* STEIN

Fig. 25.

*Dinophysis hastata* STEIN, 1883, Pl. 19, Fig. 12: PAULSEN, 1908, p. 12, Fig. 9: OKAMURA, 1912, p. 19, Figs. 73-75: JÖRGENSEN, 1923, p. 31, Figs. 40-41: KOFOID & SKOGSBERG, 1923, p. 261, Figs. 32, 38: PAVILLARD, 1923, Fig. 2 a: LEBOUR, 1925, p. 83, Fig. 21 e: SCHILLER, 1931, p. 138, Fig. 131 a-n: WOOD, 1953, p. 199, partim, Fig. 47 a.

Syn.: *Dinophysis uracantha* STEIN, 1883, Pl. 20, Figs. 22, 23: SCHÜTT, 1895, p. 16, Pl. 2, Fig. 9: PAVILLARD, 1923, p. 870, Fig. 2 b: JÖRGENSEN, 1923, p. 31 Figs. 42-43; LEBOUR, 1925, p. 83,

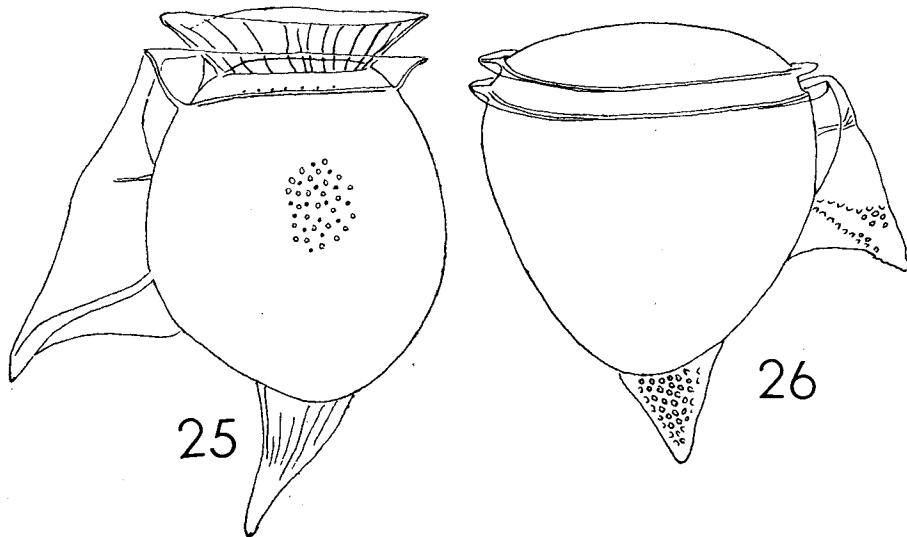


Fig. 25. *Dinophysis hastata* (STEIN).

Fig. 26. *Dinophysis doryphorum* (STEIN).

Fig. 20 g: KOFOID & SKOGSBERG, 1928, p. 273, Fig. 35: SCHILLER, 1931, p. 142, Fig. 134 (after KOFOID & SKOGSBERG.)

*Dinophysis monacantha* KOFOID & SKOGSBERG, 1928, p. 283, Fig. 37<sub>2-3</sub>.

*Dinophysis ureolus* KOFOID & SKOGSBERG, 1928, p. 281, Fig. 37.

During his sojourns at the Shimoda Biological Laboratory, the present author had rather rarely chances to observe some specimens most probably referable to one or others cited above, but at the same time showing some features intermediate between them. Very unfortunately, he could not carry out the detailed morphological analyses of those specimens. Consequently, these specimens are recorded here under the name of *D. hastata* as a collective species.

Dimension: 53-74  $\mu$ .

Distribution: Specimens of these types are reported as eupelagic.

### *Dinophysis doryphorum* (STEIN)

Fig. 26.

Syn.: *Phalacroma doryphorum* STEIN, 1883, p. 23, Pl. 19, Figs. 1-4: SCHÜTT, 1895, p. 56, Pl. 4, Fig. 19; 1899, p. 42, Pl. 6, Fig. 17: OKAMURA, 1912, p. 27, Pl. 5, Fig. 77 a-b: PAVILLARD, 1916, p. 47, Fig. 12, Pl. 3, Fig. 8: FORTI, 1922, p. 104, Fig. 107: JØRGENSEN, 1923, p. 16, Fig. 17: KOFOID & SKOGSBERG, 1928, p. 175, Fig. 23: SCHILLER, 1931, p. 99, Fig. 91: ?WOOD, 1953, p. 191, Fig. 30 a, b.

*Phalacroma doryphoroides* DANGEARD, 1927, p. 380, Fig. 44 b, c.

This was found at times in the plankton samples collected from Sagami Bay. Variations were established in size, length, locating site and extending direction of the antapical sail, as in the case of the preceding species. Judging from the sites of the second and the third ribs of the left sulcal list, the total length of the paired ventral hypothecal plates seems to be a little less than one-third of the dorso-ventral dimension of the epitheca, and stretched in the anterior 0.4 of the hypotheca; the anterior moiety is seemingly about one third as long as the other moiety. In the preceding species, the total length of the paired ventral hypothecal plates corresponds to the dorsoventral dimension of the epitheca and to a half of the length of the hypotheca.

Dimension: Length, 63-74  $\mu$ . Greatest dorso-ventral dimension, 57-63  $\mu$ .

Distribution: Sagami Bay. This eupelagic species is widely distributed in the tropical and the subtropical warm waters.

### Genus *Proheteroschisma* TAI & SKOGSBERG

Basing on the observation of a single specimen, TAI & SKOGSBERG (1934) proposed a new genus, *Proheteroschisma*, probably associating it with *Heteroschisma*; both of these genera have similarly a "postcingular plate". Judging from the authors' Fig. 12 E, undisjoined anterior ventral hypothecal plate and a postcingular plate were misinterpreted as to form a unified plate, because in that figure a suture-like line is drawn

along the lateral of the base of the isolated anterior portion of the left sulcal list and a rib-like figure is given at the anterior end of the suture in the cingular-sulcal list. The fission (=the authors' main) rib lies shortly in front of the middle of the left sulcal list; this shows undoubtedly that this form is a regular member of the *Dinophysis*—*Citharistes* group. It is not certain, however, whether the differentiation of the postcingular plate is a constant character or due to mutation, but in all probability due to mutation. TAI & SKOGSBERG established this genus basing only on a single specimen collected from Monterey Bay. Then, the discernment of the so-called "postcingular plate" in this form as a generic character is highly questionable. This shall be discussed further on in relation to *Heteroschisma*.

#### Genus *Dinofurcula* KOFOID & SKOGSBERG

Scarcely any was recorded on the thecal morphology of both *Dinofurcula ultima* and *Dinofurcula ventralis*. According to KOFOID & SKOGSBERG (1928, p. 206), the left sulcal list stands along the entire length of the sulcus, and that of the latter species "appears to have one to three ribs in its anterior half." If these descriptions are correct, the ventral hypothecal plates must lie along the entire length of the sulcus and the anterior moiety of them may be extremely small just as the anterolateral plate of *Metaphalacroma*, so far as illustrated in Fig. 6 of Plate 5. Anyhow, the details are quite unknown, and the allocation of this genus in the *Dinophysis*-*Citharistes* group is tentative.

#### Genus *Histiophysis* KOFOID & SKOGSBERG

A single specimen of *Histiophysis rugosa* was recorded by KOFOID & MICHENER (1911) and it was assigned to this new genus by KOFOID and SKOGSBERG (1928) who described "Left sulcal list ends somewhat ventrally to antapex," and "no main rib behind fission rib." Judging from the figure given by the latter authors, the left sulcal list is divided into the anterior and the posterior subequal halves; the anterior of which is ornamented with reticulation quite different from that found on the posterior half and its posterior end coincides with the rear end of the right sulcal list. These suggest that the posterior end of the sulcus corresponds to that of the anterior half of the left sulcal list, and at the same time the anteroposterior arrangement of the ventral hypothecal plates is apparently valid.